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A Revision of the Genera and great Groups of the Echinoidea.

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### I.

Introduction:—the necessity for a Revision of the Fossil and Recent Genera of the Class Echinoidea and for a reconsideration of the arrangement of the great groups.—Definition of the Class Echinoidea and of its Subclasses the Palæechnoidea and the Euechinoidea. Remarks upon the Palæechnoidea, their Classification.—Definitions of the Orders and Genera.

THE last work of L. Agassiz and Desor, "Le Catalogue Raisonné des Familles, Genres, et des Espèces de la Classe des Échinides," was published in the 'Annales des Sciences Naturelles' during 1846-7, and was a magnificent conspectus of all their previous labours in the classification of both the fossil and the recent Echinoidea. The work formed the foundation of a vast superstructure, which, however, soon separated into studies of the fossil species and genera apart from those of the recent fauna. Desor gathered together all the information regarding the fossil forms up to 1858, when he published his 'Synopsis des Échinides fossiles.' This standard work has been of great value to palæontologists. The history of the Zoology of the recent Echinoidea, subsequently to the date of the 'Catalogue Raisonné' and up to 1883, and also a previous 'Revision of the Echini' (1872-4) were the contributions of Alexander Agassiz. The Reports on the Echini of the 'Hassler,' 1874, 'Challenger,' 1881, and 'Blake,

1883, Expeditions, by this author, contain nearly the whole of the systematic and much of the morphological knowledge of the recent fauna. The work of Desor, and those of A. Agassiz, the one on the fossil, and the others mainly on the recent genera and species, are invaluable and have formed the basis of all subsequent research. But no book has appeared which has been written by any naturalist who has personally laboured in the classification and morphology of the Class, which has treated of both the fossil and the recent genera. Palæontologists have published great numbers of genera and species since the days of Desor, and have not invariably paid attention to the progress of their fellow workers who have described recent forms. And, on the other hand, much that was written a few years since by some naturalists, dealing with recent forms, would not have seen the light had careful descriptions of fossil genera, such, for instance, as have been published by Cotteau, de Loriol, and Sven Lovén, been available in a standard work of reference. The results of this division of labour and of the independent researches of Palæontologists and Zoologists have been the adoption of too many genera and the production of much confusion in the nomenclature; and the recognition of genera and species, both fossil and recent, has been rendered difficult by the publication of their diagnoses in the Journals of learned Societies, and in the works of Geological Surveys of nearly every civilized country.

The progress of the morphology of the recent Echinoidea has been great, and it chiefly dates from the time of J. Müller (1854) and the subsequent publication of S. Lovén's 'Études sur les Échinoïdées' in 1874; it was maintained by the author of the 'Revision of the Echini,' and much valuable new matter is to be found in the 'Challenger' and 'Blake' Reports. Lovén's wonderful work on *Pourtalesia* and his later contributions, together with the results of the work of Sir Wy. Thomson, and of Messrs. Norman, Stewart, Ludwig, H. Carpenter, Sladen, Hamann, Sarasin, and Bell, and of some publications in the Journals of the Linnean and Geological Societies of London, have rendered some modifications in the terminology and of the taxonomic value of certain structures absolutely necessary. It is the belief of all practical Echinologists that a work which would collect the generic descriptions of both the fossil and recent faunas, and which would revise and eliminate when necessary, by the light of modern morphology, is very

urgently required. Hence in this "Revision of the Genera and great Groups of the Fossil and Recent Echinoidea," the Author has endeavoured to remedy an urgent want. He has had unusual advantages and opportunities for studying fossil and recent Echinoidea; and in this endeavour to utilize them he is under great obligations to his friend A. Agassiz and to the able naturalists and palæontologists connected with the British Museum, the Museum of Practical Geology, the Woodwardian Museum at Cambridge, to his colleague in the description of the Sindian Fauna, Mr. Percy Sladen, and last, but by no means least, to his kind and generous friend Sven Lovén.

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NOTE.—It will be noticed that many genera no longer find a place in the classification, but are either removed entirely or placed as subgenera, and, as the intention was to limit the genera rigidly, very few new ones are introduced. In describing every genus, the name which comes immediately after the generic term is that of the founder, and when it is in roman type it may be assumed that the original definition was improved by the naturalist whose name stands next. The names placed after the first one, even when this is not in roman type, are those of subsequent investigators and describers of species who have added to the value or have modified the original diagnosis of the genus. When any anatomical details have been described relating to a genus, the name of the investigator has been added. The references, as a general rule, refer to the date, volume, and page of works in which there are illustrations; but, to save space, the number of the plate is not given, especially as it will be found upon the page referred to. The distribution of the genera has, of necessity, been considered, but the great geological formations alone are noticed in dealing with the fossil forms. A description of the terms employed in the classification will be found at the end of the Essay.

The synonymy adopted by A. Agassiz in his 'Revision of the Echini,' 1872-1874, is accepted.

The classification of Dujardin et Hupé, in 'Les Suites à Buffon,' was a useful but not critical literary work, being a compilation. M. Pomel's "Thèses," Algiers, 1883, contain a classification which is not followed in this communication, for the fundamental methods employed do not commend themselves, it being impossible to admit genera which are not differentiated by characters which have a decided and important physiological value.

## Subkingdom ECHINODERMATA.

### Class ECHINOIDEA.

Echinodermata with a solid or slightly flexible test covering the viscera, variable in shape from spheroidal to flat, composed of numerous, closely placed, more or less geometrical plates of carbonate of lime, covered with soft structures and carrying spines. Most of the plates arranged in several vertical series, reaching from the mouth to the dorso-central or apical system, constituting five ambulacral and five interradial areas. Other plates in the dorso-central system—the basal and radial and anal plates. With a mouth on the under or actinal surface, rarely in front of the test, and an internal gullet and intestinal tract ending externally in an anus, which is either placed in the dorso-central system or somewhere in the posterior interradium. A madreporite body placed in the dorso-central system and in relation with a renal organ and with the water-system, which is partly within the test and partly external, in the form of branchiæ and branchial tentacles. With or without five teeth in jaw-pieces, which are moved by muscles connected with a connected or disconnected perignathic girdle.

Unisexual or bisexual; the genital glands with ducts perforating the basal plates or opening beyond them; the young, either undergoing metamorphoses and being free-swimmers, or found perfect upon the parent's test.

Marine: fossil and recent.

#### I. Subclass. The PALÆECHINOIDEA, *Zittel* (amended).

Echinoidea with only one, or with more than two, vertical rows of plates in each of the five interradia, and with either two or many vertical rows of simple or compound plates in each of the five ambulacra; plates of the areas overlapping or not. Peristome actinal. Jaws present. Periproct within the dorso-central system or in the posterior interradium beyond.

#### II. Subclass. The EUECHINOIDEA, *Bronn*.

Echinoidea with two vertical rows of plates in each of the five interradia, and a similar number of vertical rows of simple or of compound plates in each of the five ambulacra. Peristome actinal,

rarely anterior; jaws and teeth present or absent. Periproct either within the dorso-central system or in the posterior inter-radium.

I. Subclass *PALÆECHINOIDEA*.

The Palæechinoidea have gradually become a great group which is readily separable from all the other divisions of the Echinoidea. The first careful descriptions of its genera and species were given by McCoy in his "Description of the Carboniferous Fossils of Ireland;" subsequently Baily, Meek and Worthen, Hall, and J. Müller added greatly to the knowledge of the anatomy and taxonomy. In 'Les Études,' Sven Lovén summarized the information which had been obtained up to 1874 and mainly followed McCoy's classification. About the same time A. Agassiz gave some important notices of the Perischoechinidæ, McCoy, then the only group of Palæechinoidea, in the 'Revision of the Echini' (p. 644). In the course of his observations A. Agassiz criticised the classifications of previous authors, and very properly drew especial attention to the discovery of J. Müller regarding the overlapping of the coronal plates of some genera, and he compared this phenomenon with the imbrication of the peristomial plates of *Cidaris* and of the coronal plates of the Echinothuridæ. It became evident that a new taxonomy of the group was necessary, and Messrs. R. Etheridge, Junr., and W. Keeping contributed papers (1874-6) to the Geological Society of London, in which the limits of the new classification were fairly stated.

Discoveries of some remarkable forms, such as *Bothriocidaris*, Schmidt, 1874, *Tiarechinus*, Neumayr, 1881, and the reconsideration of *Echinocystites*, Wy. Thomson, 1861, necessitated the introduction of groups which could not be placed as Perischoechinidæ. Zittel gave an admirable classification in his 'Palæontologie,' 1876-80; and finally A. Agassiz introduced some pages in his Report on the 'Challenger' Echini, 1881, which are full of most valuable matter. He had the opportunity of studying the rare species described by American palæontologists, of which plates and figures alone have been noticed by European geologists, and he brought to bear on their consideration a vast amount of knowledge about the recent Echini and especially of the Echin-

thuridæ. The descriptions of some genera by Meek and Worthen and McCoy require additions, in consequence of this work of A. Agassiz.

The foundation of a classification upon the presence or absence of primary tubercles upon tests was due to McCoy, and it served its time; but it was too artificial and permitted genera to be closely associated which had structural differences of great physiological importance. For instance, some genera with two and with more than two vertical rows of ambulacral plates were associated closely; moreover, genera which had bevelled plate-edges, and where there was overlap, were associated with forms which had rigid tests and no overlap of plates. It must be admitted that too much has been made of the presumed and real imbrication of plates in classification.

Whilst it is undeniable that our knowledge of the genera of Palæechinoidea has increased, it is still necessary to remember that any classification must be open to exception. It is not possible to place some of the genera in the same groups upon the admitted principle of the preponderating taxonomic value of the structure of the ambulacra, and, indeed, there must be some anomalous genera; but the following grouping is suggested as the best at the present time.

All genera founded in reference to single plates or spines are not considered, and *Eocidaris*, Keyserl., is omitted, for it is a true Cidarid. *Palæocidaris*, Beyr., is synonymous with *Lepidocentrus*, J. Müller. *Perischocidaris*, Neum., is the same as *Perischodomus*, McCoy. *Echinocrinus*, Ag., and *Palæocidaris*, Desor, are synonymous with *Archæocidaris*, McCoy. *Protoechinus*, Aust., is the same as *Palæechinus*, Scoul. *Melechinus* is *Melonites*, Norw. & Owen. *Cystocidaris*, Zitt., is *Echinocystites*, Wy. Th. *Palæodiscus*, Salter, which was intended for an Asterid genus, really contains some Echinoidean types closely resembling *Echinocystites*; but the position of the periproct is not known.

The genera remaining after these removals and absorptions are classified under four orders of the subclass Palæechinoidea. *Bothriocidaris*, a remarkable form from the Lower Silurian formation, requires, as Zittel has shown, a special group, and an order is established for it. The Perischoechinoidea group themselves with as little friction as possible into two families, the Archæocidaridæ, with narrow ambulacra, and the Melonitidæ, with more than two vertical rows of poriferous plates in an

ambulacrum. *Tiarechinus*, so ably described by Lovén after Neumayr, is unique and must enter an order of its own. And, finally, the exocyclic *Echinocystites* comes into the order Cystocidaroida.

It is certainly supremely interesting to find jaws and teeth in these old forms and to be able to classify, thanks to Sir Wy. Thomson, an exocyclic gnathostome amongst the Palæozoic Echinoidea.

*Classification.*

SUBCLASS PALÆECHINOIDEA. (Page 5.)

ORDER I. BOTHRIOCIDAROIDA.

Genus *Bothriocidaris*, Schmidt.

ORDER II. PERISCHOECHINOIDA.

Family ARCHÆOCIDARIDÆ.

Genus *Lepidocentrus*, J. Müller.

*Koninckocidaris*, Dollo & Buisseret.

*Perischodomus*, McCoy.

*Archæocidaris*, McCoy.

*Lepidocidaris*, Meek & Worthen.

*Lepidechinus*, Hall.

*Palæechinus* (Scouler), McCoy (pars).

*Rhoechinus*, W. Keeping.

Family MELONITIDÆ.

Genus *Melonites*, Norwood and Owen.

*Oligoporus*, Meek & Worthen.

*Lepidesthes*, Meek & Worthen.

*Hybochinus*, Worthen & Miller.

*Pholidocidaris*, Meek & Worthen.

ORDER III. PLESIOCIDAROIDA.

Genus *Tiarechinus*, Neumayr.

ORDER IV. CYSTOCIDAROIDA.

Genus *Echinocystites*, Wy. Thomson, 1861.

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Order I. BOTHRIOCIDAROIDA,

*F. Schmidt*, 1874; *Zittel*, 1876-80.

Test regular, more or less spherical, solid; interradia with only one vertical row of plates which do not imbricate; ambulacra with two vertical rows of plates; plates united at their edges. Periproct in the central apical system. Peristome actinal, central. Jaws?

Genus *BOTHRIOCIDARIS*, Eichwald, 1860, *Lethæa Rossica*, p. 654.

*Fr. Schmidt*, 1874, *Mém. Acad. St. Pétersb.* sér. 7, vol. xxi. no. xi. pp. 36-38. *Zittel*, 1876-80, *Palæont.* Bd. i. p. 481. *Lovén*, 1883, *Pourtalesia*, p. 57. (*Slightly altered.*)

Test small, hemispherical or conico-hemispherical.

Apical system central dorsal, with five large broad radial plates limiting the periproct, each with two pores surrounded by a raised rim, with five small, imperforate, triangular basal plates intervening between the radial plates, entering or not the periproct. Six or eight ovoid, acuminate anal plates, each with a spiniferous tubercle.

Ambulacra wider than the interradia, straight, with two rows of plates, large, hexagonal at the ambitus, and smaller above and below; each plate with a central circular pit, with a pair of pores on its floor, and with 2-4 small, perforate, wart-like tubercles, carrying finely longitudinally-striated small spines; around is some granulation. The ambulacra end dorsally at the large radial plates and actinally at the peristomial margin, where they are moderately broad and exclude, by their contact, the interradiial plates.

Tentacles long and cylindrical. (*Lovén.*)

Interradia five in number, narrow, composed each of one row of plates subequal to the ambulacral, but smaller dorsally and actinally, excluded from the peristomial margin. Plates may have small tubercles and granules.

Peristome subcircular, margin formed by the ambulacra; five narrow triangular buccal plates project inwards.

*Fossil.* Lower Silurian: Europe.

## Order II. PERISCHOECHINOIDA, *McCoy*, 1849,

*Ann. & Mag. Nat. Hist.* vol. iii. (*Amended.*)

Tests regular, with more than two vertical rows of interradiial plates which are dissimilar; with two or many vertical rows of ambulacral plates, each with a pair of pores. Test thick and rigid, or thinner and with the plates overlapping more or less. Ornamentation variable. Jaws present.

### Family ARCHÆOCIDARIDÆ.

Perischoechinoida with narrow ambulacra, each with only two rows of poriferous plates.



Genus LEPIDOCENTRUS, *J. Müller*, 1856, *Abhandl. d. k. Akad. d. Wiss. Berlin*, p. 258. *L. Schultze*, 1867, *Denks. d. k. Akad. Wiss. Wien*, vol. xxvi. p. 123. *Lovén*, 1874, *Etudes*, p. 39. *Zittel*, 1879, *Palæont.* Bd. i. pt. iii. p. 482. *A. Agassiz*, 1881, 'Challenger' Report, p. 79. (*Amended.*)

Syn. *Palæocidaris*, *Beyr.*

Interradial areas with from five to nine vertical rows of plates at the ambitus; plates hexagonal, except close to the ambulacra, where they are quadrangular; imbrication aboral and also laterally from the median row; some projection at and over the interrado-ambulacral sutures.

Ambulacra very narrow, two vertical rows of plates, low and broad, each with a pair of pores. Beyond the peristomial margin the plates are continued to the true mouth, no distinction being possible between coronal and peristomial plates. Tubercles of the interradia distant, there being two or three upon a plate near the ambulacra; the other plates carry only one or two. Spines subulate and small, but articulated upon tubercles. Jaws exist.

*Fossil.* Devonian: Europe. Lower Carboniferous: U. States.

Genus KONINCKOCIDARIS, *Dollo & Buisseret*, 1888, *Compt. Rend. de l'Acad. des Sci. Nat.*, 26 Mars.

Shape, apical disk, and jaws unknown.

Ambulacra broad, with two vertical rows of imbricating plates; a pair of pores to a plate near the interradial edge; the pores of the pair oblique, the adoral internal and separated from the other by an oblique ridge; interporiferous area projecting, carrying numerous secondary tubercles similar to those of the interradial plates.

Interradia with seven vertical rows of polygonal plates at the ambitus, the median row the smallest; plates only twice as high as those of the ambulacra, imbricating, carrying rather distant secondary tubercles; the adambulacral plates carry a larger primary, perforated tubercle near their margin. Spines, some stouter than the others and doubtless belonging to the larger tubercles; some very delicate and slender, striated longitudinally and more or less cylindrical.

*Fossil.* Carboniferous Limestone: Europe (Belgium).

Genus PERISCHODOMUS, McCoy, 1849, *Ann. & Mag. Nat. Hist.* ser. 2, vol. iii. p. 251. *W. Keeping*, 1875, *Quart. Journ. Geol. Soc.* 1876, vol. xxxii. p. 35, pl. iii. figs. 1-5. *Worthen & Miller*, 1883, *Geol. & Pal. Illinois*, vol. vii. p. 333. (*Amended.*)

Syn. *Perischocidaris*, Neum.

Test spheroidal, depressed, subpentagonal in outline.

Apical system central, with five broadly pentagonal basal plates surrounding a small periproct, each with from 6-8 genital perforations; radial plates small; anal plates exist.

Ambulacra narrow, straight, sunken, overlapped on either side by the interradia; plates in two vertical series, numerous, small, low, broad, and either regular in shape, elongate pentagonal, or wedge-shaped, the small end of one plate in contact with the large part of its neighbour; plates overlap from the apex actinally, each with a pair of pores in simple vertical series or slightly alternating; surface minutely granular.

Interradia broad, with five vertical rows of large scale-like plates at the ambitus, diminishing in number to two or three at the apex. Plates variable in thickness, thick or thin, convex and irregular in outline, those of the middle rows the most symmetrical, trapezoidal or depressed hexagonal; plates of the middle row overlap those of the row on either side and these the other rows to the ambulacra; each plate also overlaps, with its aboral edge, the plate situated apically to it; the highest plates overlap the basal plates of the apical system.

Ornamentation granular, homogeneous, and of small and also a few large, perforate, non-crenulate tubercles with a low, depressed, broad, conical boss, placed upon a circular scrobicule. A larger tubercle upon some interradiial plates close to, or in the second row from the ambulacra, or more than one, often with a circle of the smaller kind near the edge of a plate. Jaws large; teeth large and grooved. Spines, some small, aciculate, and striated; others larger but still short, smooth and cylindrical, tapering, broadest inferiorly, without a ring or collar, striated.

*Fossil.* Carboniferous: Wexford, Ireland, and Clitheroe, England; Scotland; Europe.

(The diagram given by Keeping, *op. cit.* fig. 3, should be reversed.)

The type specimen of *P. biserialis*, McCoy, in the Woodwardian Museum, Cambridge, has a great adoral underlap of the interradiial plates.

Genus ARCHÆOCIDARIS, *McCoy*, 1844, *Synop. Carb. Foss. Irel.* p. 173. *Trautschold*, 1868, *Bull. Moscou*, vol. xli. p. 467. *J. Young*, 1873, *Geol. Mag.* vol. x. p. 302; *Proc. Nat. Hist. Soc. Glasg.* vol. ii. pt. 2, p. 325. *R. Etheridge, Junr.*, 1874, *Quart. Journ. Geol. Soc.* vol. xxx. p. 311. *Lovén*, 1874, *Études*, p. 43. *W. Keeping*, 1875, *Quart. Journ. Geol. Soc.* vol. xxxii. p. 39. *A. Agassiz*, 1881, 'Challenger' Report, p. 77. (*With additions.*)

Syn. *Echinocrinus*, Ag.; *Palæocidaris*, Desor.

Test large. Shape and apical system unknown.

Ambulacra narrow, straight, reaching beyond the peristome to the true mouth; plates irregular, imbricating adorally, each perforated by two pores; plates in two vertical rows.

Interradia with from three to five vertical rows of large, thin plates, the median hexagonal and those of the rows nearest the ambulacra more or less pentagonal, diminishing in number towards the poles, and continued beyond the peristome as small plates. The median plates are bevelled over those on either side slightly, and these over others to the ambulacral edge, which may be raised; the adoral edge of each plate with a broad groove for the reception of the corresponding aboral process of the next plate situated adorally; the plates within the peristome overlap towards the apex. Slits at the peristome for the external branchiæ.

Jaws with long, broad, grooved teeth, the pyramids rather short, upper foramen small, cheeks deeply cut.

A large primary tubercle upon each interradial plate, having a low, conical truncated boss, supporting a narrower subconical perforated mamelon, surrounded by a wide groove; scrobicule large, almost flat; plate beyond with a circlet of secondary tubercles and large granules, with concentric striations or crenulations. Spines of the large tubercles large, long, slender, bluntly serrated on the longitudinal ribs, some spines smooth, and beyond the lower third striated and with rows of oblique spinules. The annular ridge of a spine may be crenulated.

*Fossil.* Carboniferous Limestone: Ireland, Scotland, England, Wales, Europe, and N. America (Upper Coal-measures, Illinois). Permian: England.

Genus *LEPIDOCIDARIS*, *Meek & Worthen*, 1869, *Proc. Acad. Nat. Sci. Philad.* p. 79; 1873, *Geol. Illinois*, vol. v. p. 478, pl. ix. fig. 15.

Syn. *Eocidaris*, sensu, *Meek & Worthen*.

A fragment of a very large test, spheroidal, depressed. Ambulacra narrow, slightly convex; plates in two vertical rows feebly imbricated adorally, compound; the primaries alternate with demi-plates, which are pointed towards the median suture.

Interradia very broad, with eight or nine vertical rows of plates or even more, hexagonal towards the median line and pentagonal close to the ambulacra, all imbricated aborally and laterally; but the lateral overlap is from the ambulacral edge to the central plates, which are overlapped on either side. A large central tubercle on each interradiial plate, with a small, perforated, central projection for the spine; the base of the tubercle surrounded by a circular smooth depression, bordered with granular mamelons. Primary spines long, cylindrical, slender, finely striated; articular end perforated and swollen so as to form a distinct ring. Dental apparatus with the teeth grooved.

*Fossil.* Lower Carboniferous Limestone: N. America.

Genus *LEPIDECHINUS*, *Hall*, 1861, *Descr. new sp. Crinoidea, Prelim. note, Albany*, p. 18; 1867, *Twentieth Report State Cabinet New York*, p. 295. *Meek & Worthen*, 1866, *Geol. Surv. (Pal.) Illinois*, vol. ii. p. 294 (*reference to Hall*). *Meek & Worthen*, 1868, *Geol. Illinois*, vol. iii. p. 522 (note). *Lovén*, 1874, *Études*, p. 44. *R. Etheridge, Junr.*, 1874, *Quart. Journ. Geol. Soc.* vol. xxx. p. 312. *Keeping*, 1875, *Quart. Journ. Geol. Soc.* 1876, vol. xxxii. p. 36.

Test large, spheroidal.

Apical system pentagonal, made up of several ornamented plates, also a circle of small plates within the periproctal ring.

Ambulacra narrow, straight, with two vertical rows of small, low, broad plates imbricating, the adoral edge of one plate overlapping the aboral edge of the plate below it. A pair of pores to each plate.

Interradia very broad, composed of from nine to eleven vertical rows of plates, diminishing considerably in number apically, the plates nearest the ambulacra smallest; the plates imbricating laterally from the median series and from pole to pole, the

median plate overlapping at its sides its neighbours, and the aboral edge of each plate overlapping the adoral edge of the plate above. Tubercles on each of the plates of the numerous rows above the ambitus, and absent below, except upon the plates nearest the ambulacra, where they are solitary. Dental apparatus unknown.

*Fossil.* Upper Devonian and Lower Carboniferous: N. America. Carboniferous: Europe (Belgium).

Genus PALÆECHINUS, Scouler, MSS. 1839. *McCoy*, 1844, *Synop. Carb. Foss. Ireland*, p. 171 (pars). *Baily*, 1864, *Journ. Roy. Geol. Soc. Irel.* vol. i. pp. 63-65; 1865, *Geol. Mag.* vol. ii. p. 42. *Meek & Worthen*, 1866, *Pal. Illinois*, vol. ii. p. 229. *De Koninck*, 1869, *Bull. Acad. Brux.* vol. xxviii. p. 554. *R. Etheridge, Junr.*, 1874, *Quart. Journ. Geol. Soc.* vol. xxx. p. 311, pl. xx. *Lovén*, 1874, *Études*, p. 40. *W. Keeping*, 1875, *Quart. Journ. Geol. Soc.* vol. xxxii. (1876), p. 37. *Duncan*, 1889, *Ann. & Mag. Nat. Hist.* ser. 6, vol. iii. p. 196. (*Amended.*)

Syn. *Protoechinus*, Aust.; *Typhlechinus*, Neum.

Test moderate to very large, prolate or oblate spheroidal, rigid, thick.

Apical system central, with a pentagonal periproct surrounded by five large basal plates, each perforated by three canals, or one plate may have but one perforation; five small, doubly perforated radial plates, placed either within the periproctal ring or not separating the basal plates; the anal membrane with concentric plates, largest externally.

Ambulacra narrow, straight, convex along the median line and sunken in the poriferous zones, composed of two vertical rows of very numerous low, thick plates of different shapes; these are either primaries, all of which reach the ambulacro-interradial suture as well as the median ambulacral suture, or alternate plates which are more or less blocked out from the interradian suture, by the increased dimensions of the outer parts of the plates above and below; or there may be demi-plates and more or less perfect primaries in the same ambulacrum, the demi-plates being large at the interradian suture and short and pointed towards the median ambulacral line, the primaries being long and may not reach the interradian suture; compound plates rare. Pairs of pores, in two vertical rows, on each side of an ambu-

lacrum; the outer pairs either in demi-plates or in primaries, the inner pairs always in primaries, which may, however, be short; the outer row is associated with the plates, which form decided salient angles at the ambulacro-interradial sutures; pores of pairs separated by distinct septa and without peripodia, always distant from sutures. Ornamentation of ambulacra of small granules and one or more transverse rows of a few very small tubercles consisting of a flat scrobicule and a small boss.

Interradia broad, convex, with from five to eight vertical rows of thick tumid plates diminishing in number towards the poles; middle plates hexagonal, the adambulacral pentagonal and with the ambulacral edge with salient and reentering angles to fit the corresponding structures of the ambulacral plates; some obliquity of the edges of all the plates, but no true overlap. Ornamentation of numerous small, close tubercles with a flat scrobicule and a boss; there may be a linear ornamentation also; spines small, acicular, short. Jaws and teeth with a groove.

*Fossil.* Upper Silurian: England. Carboniferous Limestone: England, Ireland, Scotland, Europe; N. America.

The reasons for restricting the species of *Palæechinus* to those with two vertical rows of pairs of pores on each side of an ambulacrum and for insisting upon the presence of radial plates have been considered in a late publication (Ann. & Mag. Nat. Hist. ser. 6, vol. iii. p. 196, 1889), and the necessity for enlarging the interesting genus *Rhoechinus*, W. Keeping, has been shown in the same place. The genus *Rhoechinus* now admits the forms of Palæechini with only a single vertical row of pairs of pores on each side of an ambulacrum, such as *P. elegans*, McCoy.

Genus RHOECHINUS, *W. Keeping*, 1875, *Quart. Journ. Geol. Soc.* vol. xxxii. (for 1876), p. 37. *Duncan*, 1889, *Ann. & Mag. Nat. Hist.* ser. 6, vol. iii. p. 205. (*Amended.*)

Test small or moderate, spheroidal.

Apical system with five basal plates with several perforations; radial plates with more than one perforation; periproctal ring formed by both radial and basal plates or only by the basal plates.

Ambulacra narrow, straight, composed of a vertical row of plates on either side of the median line; plates low, broad, thick, primaries only; a vertical row of pairs of pores on each side of an ambulacrum, a pair to each plate.

Interradia with from four to five rows of plates diminishing at

the poles, irregular in shape or hexagonal in the median line and polygonal at the ambulacral edge. Ornamentation of small granules with occasional small bosses surrounded by a flat scrobicule; plates obliquely bevelled at the edges, admitting of slight overlap.

*Fossil.* Carboniferous Limestone: England and Ireland.

Family MELONITIDÆ.

Perischoechinoida with broad ambulacra composed of many vertical rows of poriferous plates.

Genus MELONITES, *Norwood & Owen*, 1846, *Amer. Journ.* 2 ser. vol. ii. p. 225. *Meek & Worthen*, 1866, *Pal. Illinois*, vol. ii. p. 227. *Quenstedt*, 1872-75, *Petr. Deutsch.* Abth. i. vol. iii. p. 381, pl. lxxv. figs. 44-50. *Lovén, Études*, 1874, p. 41. *R. Etheridge, Junr.*, 1874, *Quart. Journ. Geol. Soc.* vol. xxx. p. 313. *W. Keeping*, 1876, *Quart. Journ. Geol. Soc.* vol. xxxii. p. 395.

Syn. *Melechinus*, *Quenst.*

Test very large, ellipsoidal, grooved longitudinally; plates thick.

Apical system central, with five equal, pentagonal, tall basal plates with a corresponding number of intervening radial plates; genital perforations of the basal plates varying in number from three to five, a single pore to a radial plate. Periproct circular.

Ambulacra broad, concave on both sides of a median ridge, with ten or more vertical rows of rather geometrical or of small, low, broad plates, thin or thick, each perforated near its centre by a pair of pores, median rows the largest; some slight imbrication of the plates.

Interradia with seven or eight or nine vertical rows of plates, diminishing in number towards the poles, thick, small, hexagonal near the median lines, pentagonal next to the ambulacra and the edges festooned there for the zigzag of the ambulacral suture. Some obliquity of the edges of the plates, especially when thick. Ornamentation of very small, distant, mamillate, imperforate tubercles; on the ambulacra they are close, and upon scrobicular circles. Spines minute, acicular.

Peristome central. Jaws large, and with stout pyramids, teeth large, grooved, and long, pointed.

The obliquity of the edges of the interrarial plates is slight, and its direction and amount are insufficient for imbrication; the ambulacral plates, when thin, have some imbrication adorally and laterally.

*Fossil.* Carboniferous: England, Europe; N. America.

Genus OLIGOPORUS, *Meek & Worthen*, 1860, *Proc. Acad. Nat. Sci. Philad.* vol. xii. p. 474; 1866, *Pal. Illinois*, vol. ii. p. 247.

Test with the same general shape as *Melonites*, and the apical system also.

Ambulacra with four vertical rows of plates, each plate perforated by a pair of pores, some demi-plates amongst the primaries.

Interradia large, convex, with from five to nine vertical rows of plates at the ambitus, diminishing in number towards the poles.

*Fossil.* Lower Carboniferous: N. America.

Genus LEPIDESTHES, *Meek & Worthen*, *Pal. Illinois*, vol. iii. p. 522.

Test ellipsoidal?

Ambulacra very broad, consisting of ten vertical series of plates at the ambitus; the plates overlap adorally, and they are broad, small, low, and each has a pair of pores.

Interradia comparatively narrow, with five or six vertical rows of plates, which overlap aborally and at the sides. Tubercles very small, equal.

*Fossil.* Carboniferous: N. America.

The next genus requires careful consideration, for it was founded partly by Worthen, whose name is so familiar to students of the Palæechinoidea, and yet contains characters which appear to be due to the same cause which led some excellent observers into error with regard to the nature of the imbrication of the Echinothuridæ.

It appears that it is quite possible that the distinguished American palæontologist may have seen the plates of his type from within, and, if so, it accounts for the character which he has given the type, of the plates overlapping in a direction contrary to all other Palæechinoidea. Worthen and Miller, after noticing



this anomaly, observe that the direction of the overlap is the same as that seen in Echinothuridæ. Now there is no doubt that this mistake about the direction of the overlap of the ambulacral and interradial plates in Echinothuridæ originated with the late Sir Wyville Thomson, who wrote in 'The Depths of the Sea,' 1873, p. 158, that the overlap was of "the plates of the interambulacral areae from the apical pole towards the mouth, those of the ambulacral areae from the mouth towards the apical disk." He referred, for the purpose of illustration, to his figure 28 (on p. 157). Unfortunately this figure is of part of the *inside* of the test of *Calveria* (*Asthenosoma*) *hystrix*, Wy. Th. The direction of overlap is always considered in relation to the outside of tests. In 1874 Mr. R. Etheridge, Junr. (Quart. Journ. Geol. Soc. vol. xxx. p. 307), quoted Sir Wyville Thomson's words, and it became generally believed that the overlap of the plates of the Echinothuridæ was in the opposite direction to that of the Perischoechnoidea. But Sir Wyville Thomson also wrote in 1874 (Phil. Trans. Roy. Soc. p. 730), after the publication of Mr. Etheridge's paper, as follows:—"The plates of the interambulacral areas overlap from the mouth towards the apex, and the ambulacral plates in the opposite direction." A. Agassiz also pointed out that the overlap is normal. Again, the most striking character of Worthen and Miller's genus is the projection in the form of humps of the ambulacra near the apex. But that condition is so anomalous that one is tempted, especially after the explanation of the abnormal overlap, to believe that the reverse condition should be seen from outside, and that the humps are really marsupia seen from within the test. The genus as defined by its authors is given, but the remarks just made should have their weight.

Genus HYBOCHINUS, *Worthen & Miller*, 1883, *Geol. & Pal. of Illinois*, vol. vii. p. 331.

Test flexible, subspheroidal, consisting of 5 ambulacral and the same number of interradial areas; protuberances at the apical ends of the ambulacra (*possibly marsupial cavities*).

Ambulacra composed of numerous (10) ranges of alternating and overlapping plates, and even more at the ambitus; each plate perforated in the central part by a single pair of pores. The plates imbricate from below upwards (*probably from above downwards*).

Interradia one half as broad as the ambulacra, with five or more vertical rows of overlapping plates, which diminish in number towards the poles; the plates imbricate from above downwards (*probably the reverse*) and from the central range outward.

Surface covered with small granules for the articulation of minute spines. Jaws consisting of large subtriangular, truncated, conical pieces deeply furrowed towards the ends and perforated in the central part. Genital plates probably with four pores. The spines minute and acicular.

*Fossil.* Carboniferous: N. America.

GENUS PHOLIDOCIDARIS, Meek & Worthen, 1869, *Proc. Acad. Sci.*

*Philad.* p. 78 (under *Lepidocentrus*); 1873, *Geol. Illinois (Palæont.)*, vol. v. p. 510, pl. xv. fig. 9. Lovén, *Études*, 1874, p. 40. Zittel, 1879, *Palæont.* Bd. i. p. 482.

Fragments belonging to individuals of from 90 to 100 millimetres in diameter.

Interradia with five or more rows of plates imbricated aborally and laterally, granular, thin, rounded, convex, unequal, those nearest the ambulacra three or four times the size of the others, elliptical, higher than broad, projecting. On one surface (ventral?) there are primary tubercles one to a plate, placed centrally, and perforated, and surrounded by two smooth rings; similar tubercles on the opposite surface of the test only on the ambulacral plates. Spines subulate, finely striated longitudinally.

Ambulacra broad, with six vertical rows of small plates, variably shaped, oval, rhomboidal, or with the angles rounded; plates imbricating adorally; with a moderate-sized mamelon, and the pores in single or sometimes double pairs, in a depression.

There are also small spines and small buccal scales present.

*Fossil.* Inferior Carboniferous: N. America. Type *P. irregularis*, Meek and Worthen.

There is a singular question about the zoological position of *Palæodiscus*, Salter, for the late Sir Wyville Thomson placed it as a synonym of *Echinocystites*. There are specimens in the Museum of Practical Geology, Jermyn St., and in the British Museum; and it is tolerably evident that there are forms there which simulate the typical *Palæodiscus*, which Salter decided to be an Asteroid. Two of these forms in the British Museum are associated, and properly so, with the Palæechinoidea, but are flattened, badly preserved semicasts. The interradial parts have

several vertical rows of plates and the ambulacra are narrow, and with a multitude of small, low plates each perforated minutely by a pair of pores; as there are two pairs of pores on each side of the median line and placed nearly horizontally, the presence of two vertical rows of ambulacral plates on either side of the median line must be admitted. The peristome presents some appearance of jaws. There is not enough to define a new genus from, and certainly the reason for placing the forms in *Echinocystites* is not apparent. The alliance is with *Oligoporus*, but it is necessary to wait for better specimens. (See *Echinocystites*.)

### Order III. PLESIOCIDAROIDA.

Test small, subhemispherical, solid, with a large apical system, having large united basal plates and a central periproct. Ambulacra narrow, and with two vertical rows of poriferous plates. Interradia with a single peristomial plate, followed by three plates separated by vertical sutures. Large tubercles on the actinal surface.

Genus TIARECHINUS, *Neumayr*, 1881, *Sitzungsb. d. kais. Akad. d. Wiss. Wien*, 1882, Bd. 84, Heft i. p. 69. *Lovén, Pourtalesia*, 1883, *Kongl. Svenska Vetensk.-Akad. Handl.* Bd. xix. pp. 11, 64, pl. xiii.

Test small, flat actinally and slightly elliptical in marginal outline, subhemispherical dorsally.

Apical system very large, extending nearly halfway to the ambitus; periproctal space small, pentagonal; basals very large, the posterior the smallest, hexagonal, forming a very broad ring; genital pores two in number, one in the basals 1 and 3; radial plates pentagonal, notching the union of the basals slightly; pores absent.

Ambulacra band-like, equal, but the posterior pair are closer together than the others; straight, broadest at the peristome, made up of two vertical rows of numerous low, broad primary plates, each with a pair of pores and a small plain tubercle.

Interradia broad, actinally composed of a single peristomial plate, above which are three tall plates only, one median and the others at its sides. Ornamentation, a plain primary tubercle to each plate at the ambitus and actinally; elsewhere the test is coarsely granular, including the apical system. Sutures very

invisible; test solid-looking. Peristome large, oval-elliptical, without branchial incisions.

*Fossil.* St. Cassian-Trias: Europe.

It is to be observed that the single species of this genus, *T. princeps*, Laube sp., was diagnosed from specimens 3·8 millim. in height, 5·2 millim. in length, and 4·9 millim. in breadth.

#### Order IV. CYSTOCIDAROIDA, Zittel, 1876-81.

Test irregular (exocyclic), globular or ovoid, thin, flexible (?); madreporite central and dorsal. Ambulacra narrow, and with two vertical rows of poriferous plates. Interradia broad, with numerous vertical rows of scale-like moveable plates; periproct in the posterior interradium above the ambitus.

There has been a difficulty made about the name of the principal, if not the only, genus of this family. Wyville Thomson defined the genus very well in 1861, and employed the term *Echinocystites*, which was a good one. In 1864 Hall called a genus of Cystidea by the name already occupied by Wy. Thomson's genus. In 1876-80 Zittel, in his 'Palæontologie,' p. 480, altered Wy. Thomson's term to *Cystocidaris*, and noticed the fact about Hall's using the name *Echinocystites*, although it was preoccupied. Certainly Wy. Thomson's name must continue, and Hall's Cystidean will have to be called by something else, and *Cystocidaris* must lapse according to the ordinary rules of nomenclature.

Genus ECHINOCYSTITES, Wy. Thomson, 1861, *Edinb. New Phil. Journ.* n. ser. vol. xiii. p. 108, pls. iii., iv. (*non* *Echinocystites*, Hall, 1864).

Syn. *Cystocidaris*, Zitt.; *Palæodiscus*, Salt. in Wy. Thoms. *op. cit.* p. 116\*.

Test large, spheroidal or ovoid, thin, flexible.

Apical system central and dorsal, apparently consisting of a large madreporite only.

Ambulacra narrow, straight; plates numerous, small, low, in four vertical rows, a central pair of pores in each plate, and

\* The genus *Palæodiscus*, Salter, 1857, *Ann. & Mag. Nat. Hist.* ser. 2, vol. xx. p. 332, was considered by Wy. Thomson in the same essay as that which contained the description of *Echinocystites*, and the solitary species was stated to be flexible and the teeth were as chisels.

therefore four vertical rows of pores two on each side of a median groove.

Interradia with numerous, 6-8, vertical rows of scale-like lozenge-shaped or irregular plates, each with a small primary tubercle surrounded by a scrobicule; granules present, and the spines short, sharp, striated, and serrate. The areas appear to unite apically.

Peristome central, actinal, small, pentagonal or stellate, surrounded by marginal ambulacral and interradial plates; dense sheaves of short spines at the edge. Jaws highly developed, five pyramids; the inner, oral surface of the pyramids with strong spines\* or with striated chisel-shaped teeth. Periproct large, on a low pyramidal protuberance in an interradium, at about one third of the diameter of the test from the peristome.

*Fossil.* Upper Silurian: Scotland.

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## II.

Remarks upon the Subclass Euechinoidea, the five Orders, definitions, and of the Suborders of the second Order. Order I., the Cidaroida; the Family Cidaridæ. Section I. Genus Cidaris (note on the classification). The seven divisions of the genus; definitions; Subgenus Goniocidaris. Other genera. Section II. Order II., the Diadematoidea. The Suborder Streptosomata; considerations regarding the anatomy and classification. The Family Echinothuridæ, and Subfamilies Pelanechininæ and Echinothurinæ; the description of the genera.

### II. Subclass *EUECHINOIDEA*.

The classification of the Euechinoidea, like that of many of the great groups of Invertebrata, can be generally natural and definite; but an artificial method seems to be necessary, occasionally. Some of the "Orders" are well defined by characters of considerable anatomical and physiological value, but others are of unequal relative value, are perhaps too comprehensive, and Suborders have to be founded.

The Orders Cidaroida and Clypeastroidea, amongst the Gnathostomes, are well defined, but the discovery of the Drs. Sarasin

\* The spines at the oral surface of the pyramids are accidental, and the result of crushing.

regarding the internal branchiæ of the Echinothuridæ and Ludwig's remarks concerning the rudimentary nature of these organs in some Diadematidæ, coupled with the knowledge that in some genera of this great family the internal branchiæ are not seen, renders it impossible to classify upon the old grounds. The difficulty is where to place the Echinothuridæ, and the Temnopleuridæ, Echinometridæ, and Echinidæ in reference to the Diadematidæ and close allies, and the Saleniidæ. It is the opinion of A. Agassiz that the Echinothuridæ should be placed close to the Diadematidæ and not with the Palæechinoidæa; and it appears to be justified by facts. But the flexible forms with the ambulacral plates continued to the mouth are, as a group, not of the same taxonomic value, in reference to the Diadematidæ, as the other families just mentioned. The Echinothuridæ have subordinal characters. On the other hand, it is not possible to separate the Echinidæ, Echinometridæ, and Temnopleuridæ from the Diadematidæ; and they all belong to a suborder.

There is at present no other method possible than to separate the Gnathostomes which are endocyclic, and which have continuous perignathic girdles and external branchiæ, into two Suborders. In one the test is flexible and the branchiæ are both external and internal; and in the other the test is rigid, and the internal branchiæ are either small, rudimentary, or absent.

A difficulty occurs amongst the Exocyclic genera, and there is, at present, no satisfactory classification possible of some of the Exocyclica without teeth.

It appears to be straining a point to separate such a genus as *Discoidea* from the Order which contains *Holectypus*, but the perignathic girdle of the last-named and its jaws and teeth differ from those of the first-named genus. In *Discoidea* there is a perignathic collar with possibly the relics of ambulacral processes; but it is the opinion of Mr. Percy Sladen and the author of this Revision that no jaws were present. Lovén is of a different opinion, but still no jaws have been found. It is not possible to place *Echinoconus* with either of these genera, for the ambulacra and the peristome differ, it has most rudimentary auricles, and the perignathic girdle is reduced to more or less defined interradiial ridges, and the genus was jawless. *Discoidea* was a transition form, between the Gnathostomes and the Suborder of Cassiduloidea, and part of the dental apparatus was abolished, and degeneration of the perignathic girdle occurred. To place

the genus in a separate Suborder is not advisable; and it is perhaps best to enlarge the definition of the Order, which contains *Holectypus* as a type, so as also to include the genera with perignathic girdles of more or less continuous collar-shape, without jaws. At present our knowledge of the genera *Galeropygus* and *Pachyclypeus* is so defective that they must remain *incertæ sedis*.

The abolition of the toothless Irregulares (Exocyclica) as a group assists the definition of the Cassiduloidea, for *Phylloclypeus*, *Conolampas*, and even *Echinoconus* can enter it, only the latter genus being, possibly, somewhat artificially placed. The separation, made many years since by Desor, between the Cassiduloids with a floscelle and without that important peristomial character, holds good, and the only difficulty in the taxonomy is to place the few genera which have, besides some Cassiduloid characters, the dissimilarity of the ambulacra characteristic of the Spatangoida, and variable apical systems, such as *Eolampas*, *Archiacia*, *Claviaster*, *Asterostoma*, &c. These genera are aberrant, yet they link the Cassiduloidea with the Spatangoida in an Order. They form a new Family, the Plesiospatangidæ.

The classification of the great group of Spatangoida—a Suborder—has been rendered difficult in consequence of the discovery of the abyssal forms. Under the hands of Lovén\* and A. Agassiz† the suborder has become manageable, and its Families are those of the Ananchytidæ, Spatangidæ, Leskiidæ, and Pourtalesiidæ. The Spatangidæ contain four well-marked types, but they do not appear to be worthy of subfamily distinction, for their separating characters are rather artificial and are of unequal value. The divisions are those insisted upon by Lovén, namely, the genera without fascioles, those without a subanal fasciole, those with a subanal fasciole, and those which are apetaloid. These are the divisions of Adetes, Prymnadetes, Prymnodesmia, and Apetala.

The attempt is made, in this revision, not to overvalue the characters of perforation and crenulation or of the plain and imperforate nature of primary tubercles. The physiological value of crenulation is very slight, it often occurs or is absent in the

\* 'Études' and 'Pourtalesia.'

† Report on the 'Challenger' Echini.

same species and specimen, and it and the opposite condition will not distinguish genera for the future\*.

The nature of the ambulacral plates, the arrangement of the pairs of pores, and the shape and functions of the tentacles are, however, considered to be of great taxonomic importance. The great importance of the radial plates, formerly erroneously considered to have a reference to an optic organ instead of a primary tentacle, is not admitted; and M. Pomel is not followed when he endeavours to establish genera and subgenera upon the entrance or not of one or more of the radial plates within the periproctal ring. Following A. Agassiz, the structure and shape of the spines are considered of secondary importance in classification, and genera are not separated on account of dissimilarities in the spines, nearly or quite all other structures being the same. These remarks will account for a proceeding which may take some palæontologists by surprise, namely, the absorption of *Pseudo-diadema* into the previously diagnosed genus *Diadema*, and the union with this last of many subgenera which were formerly considered to be genera.

## II. Subclass *EUECHINOIDEA*.

I. Order.—Euechinoidea with an actinal, central peristome and an abactinal periproct, situated within the dorso-central system; with internal branchiæ only, and having jaws and more or less vertically placed teeth, and a discontinuous perignathic girdle; the interradial as well as ambulacral plates continued beyond the peristome to the true mouth. Spheridia absent. Endocyclic, anectobbranchiate, Gnathostomes.

### CIDAROIDA.

II. Order.—Euechinoidea with an actinal, central peristome and an abactinal periproct situated within the dorso-central system; with perfect or rudimentary or absent internal branchiæ, with external branchiæ and incisions in the peristome; with jaws and teeth and a continuous perignathic girdle; ambulacral plates alone continued beyond the peristome or as separate buccal plates. Spheridia present. Endocyclic, ectobbranchiate, Gnathostomes.

### DIADEMATOIDA.

\* Ann. & Mag. Nat. Hist. 1888, pp. 120-122.



1. Suborder STREPTOSOMATA.—Test more or less flexible, with external and internal branchiæ. Ambulacral plates alone continued beyond the peristome to the stoma.
2. Suborder STEREOSOMATA.—Test rigid, with external branchiæ and rudimentary or absent internal branchiæ; with isolated buccal ambulacral plates.

III. Order.—Euechinoidea with an actinal, central peristome, and the periproct situated beyond the dorso-central system in the posterior interradium; with external branchiæ; with a pair of pores or only one pore to an ambulacral plate; with feeble jaws and vertical teeth, or without these structures; with a variably constructed perignathic girdle. Spheridia present. Exocyclic, oligoporous, Ectobranchiata.

HOLECTYPOIDA.

IV. Order.—Euechinoidea with an actinal peristome, a periproct situated beyond the dorso-central system, in the posterior interradium; with external branchiæ; with tentacular pores in the interradia, and more than a pair to an ambulacral plate; tentacles heteropodous in arrangement; with more or less horizontal and rarely vertical teeth, and with jaws situated superiorly to the disconnected perignathic girdle. Spheridia present. Exocyclic, petalobranchiate, polyporous, Gnathostomes.

CLYPEASTROIDA.

V. Order.—Euechinoidea with an actinal or a frontal peristome, and a periproct situated beyond the dorso-central system, in the posterior interradium; without external branchiæ, jaws, teeth, and perignathic girdle. Spheridia present. Exocyclic, anectobranchiate, Nodostomata.

SPATANGOIDA.

1. Suborder CASSIDULOIDEA.
2. Suborder SPATANGOIDEA.

Subclass II. *EUECHINOIDEA*.

## Order I. CIDAROIDA (p. 24).

Family CIDARIDÆ, *Agassiz & Desor*, 1846, *Catal. Rais., Ann. Sci. Nat.* vol. vi. p. 325 (pars). *Joh. Müller*, 1854, *Abh. d. k. Akad. d. Wiss. Berlin*, p. 123. *Desor*, 1858, *Synopsis*, p. 2 (pars). *Wyv. Thomson*, 1874, *Phil. Trans.* vol. clxiv. p. 720. *A. Agassiz*, 1874, *Revision*, pp. 251 & 384 (pars)\*.

Test spheroidal; the ambulacra narrow, with two vertical rows of very numerous low plates, which are primaries, and rarely become compound, united by their edges, each with a pair of pores arranged in single and rarely in double series; other plates continued from the peristome to the true mouth and imbricating, besides being perforated; interporiferous areas with large and small granules only.

Interradia broad, with few plates in two vertical series, most with a large primary, scrobiculate tubercle, carrying a large spine, secondary tubercles and granules with smaller spines; plates united at their edges; some broad and low plates continued from the peristomial margin to the true mouth, and imbricating.

Apical system large, with five basal plates and five radial plates, each with a perforation; periproct in the midst, covered with plates. A madreporite in the right anterior basal plate.

Jaws with the foramen of the pyramid small, and not closed in by epiphyses; teeth grooved; perignathic girdle discontinuous, with a bifid process on each interradium only. Branchiæ internal; tentacles subheteropodous †. Peristomial branchial incisions and external branchiæ absent. Spines variable. Spheridia absent.

\* A. Agassiz pointed out in the 'Revision' that the anatomical researches of Johan. Müller rendered a correct definition of the family Cidaridæ possible. But nearly all the definitions which have been recorded have been too synthetic. Since A. Agassiz gave such a mine of information regarding the recent genus *Cidaris* and its subdivisions, there has been a general movement towards simplification. The old subfamily "*Salenidæ*" has been eliminated and the fossil and recent Cidaridæ form a tolerably homogeneous group. In the Report on the 'Challenger' Echini, 1881, A. Agassiz remarks concerning the branchial slits at the true mouth of recent specimens of *Cidaris* (p. 53):—"Whether it is these organs (gills) which find their way through the cuts or not, in our Florida species, I am unable to state; and a renewed examination of living specimens will be necessary before we can settle this interesting question."

† The definition of terms is given at the end of this Essay.

Order CIDAROIDA.

Family CIDARIDÆ.

Section I. Ambulacral pairs of pores uniserial.

Genus *Cidaris*.

Subgenus *Goniocidaris*.

Genus *Orthocidaris*.

*Temnocidaris*.

*Polycidaris*.

Section II. Ambulacral pairs of pores biserial.

Genus *Diplocidaris*.

*Tetracidaris*.

Section I.

The first genus of the Cidaridæ is *Cidaris*, Agassiz and Desor, 1846; and it is a very large one. Nevertheless it is well differentiated from any other genus; and it would be easily defined had not a series of artificial divisions, raised to the dignity of subgenera and even of genera, been employed to group the species. It is best to give the amended generic definition, and then to consider the grouping of the species.

GENUS CIDARIS, Klein, 1734 (pars); Lamarck, 1816 (pars); Gray, 1825 (pars). *Agassiz & Desor*, 1846, *Cat. Rais., Ann. Sci. Nat.* vol. vi. p. 325. *J. Müller*, 1853, *Bau. d. Ech., Abhl. d. k. Akad. d. Wiss. Berlin*, pub. 1854, p. 123. *Desor*, 1858, *Synopsis*, p. 3. *A. Agassiz*, 1872-74, *Revision of the Echini*, p. 252; and 1881, 'Challenger' Report, p. 33. *C. Stewart*, 1871, *Quart. Journ. Micr. Sci.* n. s. vol. xi. p. 54; and 1879, *Trans. Linn. Soc.* vol. i. p. 569. *Lovén*, 1887, *Ech. descr. by Linnæus*, pp. 138, 146.

Syn.:—*Eocidaris*, Desor, 1858\*; *Anaulocidaris*, Zittel, 1884†; *Discocidaris*, Döderlein, 1885‡; *Schleinitzia*, Studer §.

Syn., when employed as genera and not as artificial divisions:—*Stephanocidaris*, A. Agassiz ||; *Rhabdocidaris*, Desor ¶; *Leio-*

\* *Synopsis*, p. 155. † *N. Jahrb. f. Min. Bd. ii. p. 132.*

‡ *Archiv f. Naturg. Wieg. 1885, Heft i. p. 82.*

§ *Monatsb. d. k. Akad. d. Wiss. Berlin, 1877, p. 463.*

|| *Revision*, p. 393.

¶ *Synopsis*, p. 39; and de Loriol, 1883, *Cat. Rais. d. Éch. réc. à l'Île Maurice*, p. 7.

*cidaris*, Desor \*; *Phyllacanthus*, Brandt †; *Dorocidaris*, A. Agassiz ‡.

Test variable in size and thickness, spheroidal, depressed or tall.

Apical system large, either flat, and with the large geometrical basal plates weakly united, or solidly sutured; the radial plates large, separating the basals or not, and in the first case often touching the outer periproctal plates which may intrude. Basal pores large; the madreporite in the right anterior basal plate; the periproct pentagonal, variable in size, numerous plated.

Ambulacra narrow, undulating or nearly straight, composed of very numerous broad low primaries, which are perforated by single pairs of pores, the pores being variable in their distance, and may or may not be united by a groove; poriferous zones broad; interporiferous areas with vertical rows of distinct granules which are small, and may have rudimentary mamelons. The plates are continued beyond the peristomial margin to the edge of the mouth, and are low, broad, imbricating, and each is pierced by a pair of pores.

Interradia broad; coronal plates few, from 5 to 11, in each of the two vertical rows, each with a primary tubercle, scrobiculate, and perforate, may be crenulated or not. Scrobicule large, often sunken, its margin with small secondary tubercles and large granules; the space beyond the scrobicules with large miliary granules.

Peristome large, without branchial incisions; the interradial plates continued beyond the peristome to the mouth, small, low, imbricating, in double series. Spheridia absent.

Perignathic girdle discontinuous; auricular processes upon the interradia. Pyramids of jaws unclosed above by epiphyses; teeth grooved.

Spines of the ambulacra, the scrobicular circle, the miliary zones, and of the plates beyond the peristome very similar, small, straight, blade-of-oar-shaped, very close; and those of the scrobicules cling around the primary spines. Primary spines very variable, even in the same species, with a calcareous network internally and solid outside, lamellary, or fluted externally, and variously spinuled, granulate, laminated, some whorled; long, with a cylindrical or angular section, pointed or blunt; or very short,

\* Synopsis, p. 48.

† Prodr. d. Act. d. l'Acad. St. Pétersb. 1834 (Additions), p. 267.

‡ Revision, p. 254.

clubbed, and large at the blunt end; fusiform, sharp, or blunt; cylindrical and blunt, with spinules, thorns, and granules or disk-shaped expansions, or cup-shaped at the end, with spines radiating; or long, flat, expanding, furrowed and spined.

Tentacles disciferous actinally, and gradually becoming non-prehensile and branchial. Pedicellariæ large, tridactyle, gemmiform, and small and blunt-headed.

Sexes separate or not; young usually undergoing metamorphoses, rarely not, and then found upon the parent.

*Fossil.* Permian: Europe. Trias: Europe, Asia\*. Jurassic to Post-pliocene: England and Europe, N. Africa, Asia. Cretaceous to Tertiary: N. America, Egypt, and W. Africa. Tertiary: Australia.

*Recent.* World-wide.

Every writer upon the classification of the Echinoidea since Desor has complained of the unsatisfactory attempts of some of the most distinguished authorities to subdivide the genus *Cidaris*. The subdivisions gradually became subgenera; and of late these have received generic importance. The divisions were made upon very unimportant external characters; and subsequent research has proved that these structures, the variations of which led them to be considered of good diagnostic value, are of no physiological importance†. The presence or absence of perforation and crenulation of the primary tubercles, and the connection of the pores of pairs by a groove, or their disconnection by a granule or swelling, have really been the main features relied upon to establish divisions, subgenera, and finally genera. Common observation will satisfy anybody that crenulation is not invariable upon the same test in many instances; and it is a mistake to believe that it is a structure which relates to the strength of the spine-muscles. These are attached to the edge of the scrobicule, and are inserted just below the milled ring of the spine; and they have nothing to do with the crenulation. This appears to add to the attachment surface of the membrane of connective tissue which closes the ball-and-socket joint of the spine and tubercle.

The grooving, or the reverse condition, between the pores of a pair is of no physiological importance whatever; and it is frequently impossible to decide whether the pores are connected by a groove or not.

Any classification in which these characters are used is artificial.

The number of interradial coronal plates is of physiological importance;

\* *Eocidaris* = *Cidaris* has been found in the Salt Range, British India.

† Duncan, 1888, Ann. & Mag. Nat. Hist. vol. i. p. 124.

and there is a great temptation to consider typical *Cidarids* as having but a few, say not more than seven, in a vertical row.

But all the other structures, or the varieties of structures, are to be noticed in combination with few or many plates. The spines of some species are apparently so peculiar that they have been used as classificatory data of primary importance; and one subgenus has been founded upon them. But A. Agassiz very properly now lays down the law that *Cidarids* cannot be classified by their spines alone. The nature of the apical disk is very different in some Cretaceous and recent species: in the former it is solid, and with a tall basal ring and a small pentagonal periproct in some well-known forms; and in the latter it is large, flat, with feebly united plates, the radial plates sometimes separating (with or without the assistance of some periproctal plates) the basals. But there is every link in the intermediate chain of structures to be seen, and even in the same species there are variations in relation in the position of the basals and radials, entry or not of the latter taking place within the ring. The size of the miliaries and the occasional want of perfection of the tubercles of the interradial plates close to the apex cannot be of any great importance.

Both Lamarck and Agassiz, and subsequently Desor, insisted upon the subdivision of *Cidaris*, in reference to the condition of the primary tubercles and the grooved or not nature of the test between the pores of pairs. Desor thus established *Rhabdocidaris* and *Leiocidaris*; Brandt established the subgenus *Phyllacanthus* from the nature of the spines and straightness of the ambulacra. A. Agassiz decides against *Leiocidaris*, and adds to the diagnosis of *Phyllacanthus*; and he introduces *Dorocidaris*, which is a true *Cidaris* with non-crenulate tubercles. De Loriol and M. Cotteau have both altered the range of diagnosis in *Rhabdocidaris* and *Leiocidaris*; and the first-named naturalist decides against *Leiocidaris* and *Phyllacanthus*.

It appears, after having given the subject careful consideration, that none of these divisions is worthy of a true subgeneric position, but that *Rhabdocidaris*, *Leiocidaris*, *Dorocidaris*, *Stephanocidaris*, *Phyllacanthus* (Brandt), A. Ag., and *Porocidaris* are fairly useful artificial divisions. They are synonyms of *Cidaris*, however. *Goniocidaris* is a good subgenus.

## I. DIVISION. Typical *Cidaris*.

If the system of subdividing the genus artificially is adopted, the typical species will be those with a small number of interradial coronal plates (5-8), and with the ambulacra more or less undulating, the pores of pairs rather close and separated by a nodule or ridge, and the primary tubercles perforated and crenulated.

The other divisions will be as follows:—

II. DIVISION. Syn. Genus *Rhabdocidaris*, Desor, 1848, Synopsis, p. 39.

Large swollen tests, often as high as broad; remarkable on account of the particular structure of the poriferous zones, which are broader than in true *Cidaris*, the two pores of a pair being distant, and linked by a groove which is small and horizontal. Ambulacra in general straight or slightly flexuous. Tubercles large, always strongly crenulated (at least in the fossil species), and proportionally more numerous than in true *Cidaris*. Scrobicules large, often elliptical. Miliary zone broad. Spines very stout, some cylindrical or prismatic, and furnished with dentations or spines, and others in the shape of oars, either simple or with spines at the base. Articular facette very large and strongly crenulated. Neck little or not constricted.—(Type, *Cidaris copeoides*, Cott., and *C. guttata*, Cott.)

III. DIVISION. Syn. Genus *Leiocidaris*, Desor, *op. cit.* p. 48.

Large tests, with smooth tubercles; but they differ from *Cidaris* because the pores of a pair are linked by a small groove, as in *Rhabdocidaris*. Miliary zones very broad. Spines as large smooth cylinders, resembling those of *Heterocentrotus*. Desor defines *Leiocidaris* as *Rhabdocidaris* with uncrenulated tubercles.—(*Cidaris canaliculata*, Dunc. & Sladen, Foss. Ech. Sind, Pal. Ind. ser. xiv. p. 109, 1884, is a good type.)

IV. DIVISION. Syn. Subgenus *Dorocidaris*, A. Agassiz, 1872, Revision, p. 254.

Ambulacral median area narrow; a small number of inter-radial plates; scrobicules sunken, and median space also. Tubercles without crenulations, and the pores of a pair without an intermediate groove. It will be observed that the spines are very variable in this division.

*Dorocidaris* is a true *Cidaris*, with no crenulation on the tubercles.—(*Cidaris papillata*, Leske, is the type.)

V. DIVISION. Syn. Genus *Stephanocidaris*, A. Agassiz, 1872, Revision, p. 393.

Test thin. Apical system larger than the peristome, the plates feebly united, and the whole flexible; the polygonal basal plates separated by large radial plates.—(*Cidaris bispinosa*, Lmk., is the type.)

VI. DIVISION. Syn. Subgenus *Phyllacanthus*, Brandt, 1834, Rec. d. Actes de l'Acad. Imp. d. Sci. de St. Pétersb., pub. 1835, Additions, p. 267; A. Agassiz, Revision, 1873, p. 387. (*Amended.*)

Test large, swollen, comparatively thin, and with the maximum of coronal plates, 8-11. Apical system large; the basal plates in contact, or separated by radial and anal plates. Ambulacra almost straight or very slightly undulating, broad; the pores in a broad zone, and united by a groove. Primary tubercles of the interradia large, perforate, non-crenulated, scrobicular circle large, areola sunken, mamelon small. Miliary area wide. Spines mostly solid, the primaries varying greatly in shape and size, cylindrical, triangular, flattened in section, elongate or club-shaped, blunt or pointed; flutings strong, either as simple striation, or as continuous or broken lamellæ variously projecting, sometimes forming secondary spinules.—(*P. dubia*, Brandt. See Lovén's remarks upon the subgenus in 'Echin. described by Linnæus,' 1887, p. 148.)

VII. DIVISION. Syn. Genus *Porocidaris*, Desor, Synopsis, pp. 46, 47. Wy. Thomson, 1874, Phil. Trans. p. 726.

Ambulacra broad and straight; pores wide apart, united by a groove. Primary interradial tubercles with small perforate and crenulated mamelons; the scrobicules more or less transversely oval, with shallow grooves more or less defined, radiating from the periphery towards the centre, along the flank of the tubercles, with or without pores or depressions at the outer extremity of the grooves. Some spines flattened, with strongly serrated edges, resembling the smaller peristomial spines of *Cidaris papillata*.—(*Cidaris purpurata*, Wyv. Thoms., the type.)

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Subgenus GONIOCIDARIS (genus), Desor, 1846, *Agassiz & Desor, Cat. Rais. d'Éch., Ann. d. Sci. Nat.* vol. vi. p. 337. *Lütken*, 1864, *Ved. Med. f. Nat. Kjöbenh.* p. 137. *A. Agassiz*, 1873, *Revision*, p. 395.

Test high; coronal plates numerous; ambulacra narrow; the median sutural regions of interradia and ambulacra sunken, forming with the horizontal sutures a zigzag, culminating in pit-like depressions at the angles of junction of the sutures.



Spines variable, either long, cylindrical, and pointed, the surface having thorns, pointing irregularly outwards, or short, stout, cylindrical or flat in outline, with enlarged cup-like tops with a fringe of strong radiating spinules; spinules in vertical series along the stems or restricted to the edge, in the flat specimens.

Viviparous, unisexual.

*Fossil.* Tertiary: Sind, Asia.

*Recent.* Philippines; Indian Archipelago; East Indies; Australia, N. South Wales; Tasmania; Falkland, Marion, and Kerguelen Islands; Patagonia; Antarctic Ocean; Natal; Zanzibar.

Wy. Thomson and Studer discovered about the same time, in 1876, that *Goniocidaris* was viviparous, and that the young were carried upon the apical system, protected by the upper spines of the test, until their full development took place. Studer, 1876, Berl. Akad. Monatsb. p. 455, noticed the large genital openings covered by a thin membrane; and Thomson described the method of carrying the young, and that the female genital openings notch the edge of the basal plates (Journ. Linn. Soc. vol. xiii. 1876; and Voyage of the 'Challenger,' vol. ii. p. 228). It is necessary to admit the unisexual nature of the species\*.

Genus *ORTHOCIDARIS*, Cotteau, 1862, *Pal. Franç., Terr. Crét.* vol. vii. p. 364.

Syn. *Hypodiadema*, Desor (pars).

Test moderate and subspherical.

Apical system flush, pentagonal, small.

Ambulacra narrow, straight; interporiferous area with small granules, which may have mamelons, placed in several rows and without order; pairs of pores in simple straight series, the pores separated by a granule, in low primary plates.

Interradia very broad, plates numerous; primary tubercles very small, perforate and plain, distant, occupying a small portion of their plates; the scrobicules small and circular; the miliary areas large, and the granules with mamelons.

Peristome small, narrow, without branchial incisions; the interradial lips the largest.

*Fossil.* Lower Cretaceous: Europe.

\* Genus *Discocidaris*, Döderlein, from Japan, has large outer anal plates and disciform ends to the primary spines; and it is a *Cidaris*. *Anaulocidaris*, Zittel, is too close to *Cidaris* to be considered otherwise than a species.

*Schleinitzia*, Studer, is a *Cidaris*.

*Eocidaris*, Keyserl., now appears to have all the requisite structures to classify it with *Cidaris*, and thus the genus is carried back in time to the Permian age.

The next three genera are not satisfactory.

Genus TEMNOCIDARIS, *Cotteau*, 1863, *Pal. Franç., Terr. Crét.*  
vol. vii. p. 355.

Test large, spheroidal.

Apical system large, flush, wider than the peristome.

Ambulacra subflexuous, narrow; poriferous zones broad, the pairs of pores in simple series; interporiferous areas with small granules placed without order, except a larger row near the poriferous zone.

Interradia large; tubercles numerous and large, plain and scrobiculate; miliary areas large and minutely granular, marked with linear depressions.

Peristome moderate, subcircular. Numerous small shallow circular pits in the miliary areas and in the interporiferous areas, but scattered without order, and not in relation with the sutures or their angles of junction.

*Fossil.* Cretaceous: Europe.

The pits do not resemble those of the *Temnopleuridæ*; and there is a suspicion of their *post-mortem* origin. Certainly the test, apart from the pits, is that of a *Cidaris*.

Genus POLYCIDARIS, *Quenstedt*, 1858, *Der Jura*, p. 644, tab. 79.  
fig. 69; 1874, *Petr. Deutschl.* p. 216, tab. 69. figs. 10-12.  
*Zittel*, 1879, *Palæont.* Bd. i. Lief. iii. p. 496.

Coronal plates low, broad, numerous in the broad interradia (9-15), two vertical rows of primary tubercles which are perforate and crenulate, and with scrobicules which run the one into the other vertically. Median interradiial area smooth, between broad angular zones.

Ambulacra very narrow, straight; pairs of pores in simple series; pores separated by a nodule; interporiferous areas with two vertical rows of very small and numerous tubercles or granules.

*Fossil.* Oolite: Europe.\*

\* *Leptocidaris*, *Quenst.*, 1858, pl. 90. fig. 10; 1874, *Petr. Deutschl.* p. 232, tab. 69. figs. 71-71y. This name was given to a fragment in which the coronal plates are numerous and low, and the pairs of pores are in simple series.

In *Quenstedt's* last work, 1874, the anatomy of an ambulacral plate is given, and it is not that of a *Cidarid*. The genus is placed after the *Hemicidaridæ*, p. 55.

Family CIDADRIDÆ.

Section II.

The ambulacral pairs of pores biserial.

Genus DIPLOCIDARIS, *Desor*, 1854-58, *Synopsis*, pp. 45 & 439.

*Cotteau*, 1862, *Rev. et Mag. Zool.* vol. xiv. p. 185, pl. 10.

Test large, spheroidal, wider than high.

Apical system large, solid, pentagonal, flush.

Ambulacra narrow, straight; poriferous zone as broad as the interporiferous area; pairs of pores very numerous, close, biserial, alternating more or less, placed in low primary plates which are single actinally, and which form compound plates elsewhere, these being double or triple combinations of low primary plates. Interporiferous area narrow, with two vertical rows of large granules with mamelons and a narrow, bare median space.

Interradia broad; plates few, high, 7-8; two vertical rows of large, perforate, scrobiculate, primary tubercles, which may or may not be crenulated, in each area; miliary zones large, with scattered granules.

Peristome narrow, with narrow ambulacral lips; branchial incisions absent. Jaws strong; the foramen of the pyramid small or absent. Perignathic girdle with interradial ridges only, and they are notched and bilobed.

Spines long, thick, cylindrical, granular, and pustulate in longitudinal ridges.

*Fossil.* Oolite: England?; Europe; N. Africa.

The next genus is placed here provisionally; it has four coronal interradial plates in each interradium, but not in every part of the areas; and the nature of the peristome is unknown in the species. The shape and the construction of the ambulacra are very remarkable; and it must be remembered that A. Agassiz found divisions in the interradial plates of *Astropyga radiata* ('Challenger' Echini, pl. x a. fig. 9, 1881).

Genus TETRACIDARIS, *Cotteau*, 1872, *Rev. et Mag. de Zool.* sér. 2, vol. xxiii. p. 445, pl. 29.

Test large, circular in equatorial outline, tumid, broader than high, depressed, spheroidal.

Apical system central, large.

Ambulacra straight, moderately broad; poriferous zones depressed, pairs incompletely biserial; plates low, primaries numerous. Interporiferous area narrow, granular, and with a vertical row of small plain tubercles, placed near each poriferous zone.

Interradia with numerous very large crenulate and perforate primary tubercles, in scrobicules, separated by a narrow median zone with few miliaries; there are four vertical rows of tubercle-bearing plates as far as the ambitus, diminishing thence to the apex by two. The plates are numerous, in vertical succession (16).

Peristome ?

Spines narrow, elongate, subcylindrical, keeled.

*Fossil.* Cretaceous : Europe.

This is a very suggestive, but at the same time, on account of the defective anatomical details, a most unsatisfactory genus.

The resemblance to *Astropyga* and the very non-Cidaridean characters of the ambulacra render the classification merely provisional. (See *Astropyga*, p. 78.)

## Order II. DIADEMATOIDA (p. 24).

It is impossible to proceed with the classification of the next important group of genera of this Order without some remarks concerning the anatomical characters of the Streptosomata and the method of classifying the Family Diadematidæ of the Stereosomata. The late Dr. S. P. Woodward described a flexible Echinoid from the Chalk in 1863, and the knowledge regarding the recent forms commenced with Grube, who described *Asthenosoma* in 1868. Then the dredgings of H.M.S. 'Porcupine' revealed to the late Sir Wy. Thomson the extraordinary spectacle of a panting, plate-moving form, which he called *Calveria*. The descriptions of the species, which turned out to belong to *Asthenosoma*, were published in the Phil. Trans. 1874, and illustrated. The importance of the "imbrication" of the plates was inculcated, and the bearing of this structure upon the classification of the Family, and upon the possible alliances with the Perischoechinidæ, was rather overstrained. Unfortunately the very arduous life and necessary

absence from England of Sir Wy. Thomson prevented him from giving more time to the study of the specimens, so that some errors were published. It is evident, however, that the mistake made about the direction of the imbrication of the plates in 'The Depths of the Sea' was corrected in the Phil. Trans. 1874. But the description and drawing of the continuation of interradial overlapping plates beyond the peristome to the true mouth were unfortunate and so was the failure to recognize the external branchiæ. Some of the internal structures were described, such as the series of longitudinal muscles running up the sides of the ambulacra, and having to do with the positive motions of the plates one over the other; but, incomprehensibly enough, the huge internal branchiæ were not recognized, and their discovery has fallen to the Drs. Sarasin in 1888! A. Agassiz, in his Report on the Challenger Echini, 1881, considered the question of the amount of the imbrication of the plates of the Echinothuridæ—its cause, nature, and its relation to bevelling in thicker Palæechnoidea. These phenomena were exhaustively and most judiciously explained.

Nothing can be more definite than the description of A. Agassiz of the construction of the test of *Asthenosoma pellucidum*, A. Ag. He remarks that the test is remarkably thin, and that even in a test of the diameter of 64 millim. the plates do not give the test any degree of solidity. The examination of a specimen of *Phormosoma luculentum*, A. Ag., in the British Museum proves the comparatively large size of some of the interradial plates, but they are excessively thin, consist of very open reticulate carbonate of lime, and they thin off at the edges, the calcareous structure being lost in the membranous part of the plate. This membranous part is continuous between plates, and the soft edge of one plate merges into the corresponding membranous part of the neighbouring plate.

In *Asthenosoma coriaceum*, A. Ag. ('Challenger' Report, pl. xvii. a. figs. 5-7), the amount of soft interplate tissue is considerable; in some places the plates show an extremely small calcareous part, and the excess of soft tissue is great. The semi-transparency of some species, when kept in alcohol, is remarkable, and the calcareous part of the plates is seen to be surrounded by a greater or less amount of soft movable, but probably not extensible, connective tissue—that is, of uncalcified plate-area. The flexibility of such tests is considerable in large parts of them,

and it is of course less when the pressure is localized; they may be bent inwards and swell out elsewhere correspondingly. During life, movements of the test occur, and it is doubtless due to the contraction and dilatation of the internal longitudinal muscles, noticed and drawn by Wy. Thomson, and so well described and drawn by the Drs. Sarasin, as well as to gravitation. During this contraction and also after death the edges of the plates, especially the transverse edges, are approximated and slip over or under each other as the case may be. Nothing can be clearer than the drawings of A. Agassiz in regard to *Phormosoma tenue* ('Challenger' Report, p. 93, pl. xviii. a. figs. 1-13). The whole of the transverse edge of a plate overlaps that of its fellow in succession. The fig. 4 has no overlap of edge, fig. 5 has it slightly, but not figs. 2, 7, 8. The amount of overriding is small, and is assisted to a small degree by the thinning of the edges of all the plates, but there is no such thing as a bevelled thick edge.

In the drawing given by Sir Wy. Thomson (*op. cit.* 1874, pl. lxxv. fig. 2), which shows the inner part of a test of *Asthenosoma* below the ambitus, the pairs of pores situated in the transverse sutural spaces are not forced out of their direction; hence the overriding must be very slight there. There is, on the other hand, definite but limited overlap of the interradiial plates. The amount of interplate membrane varies in the species of *Phormosoma*, and it is less on the whole than in those of *Asthenosoma*, and yet the amount of overlap is only partial in this genus. The species *Phormosoma rigidum*, A. Ag., has a significant name, and it is evident that the interplate membranes are reduced to their utmost; there is no appreciable space between the plates in the drawing (Report on the 'Challenger' Echini, pl. xii. a. figs. 1-4, p. 104); all the other generic characters are present, but this is not a flexible and "panting" form, and has most significant alliances with the Diadematiidæ.

The pistol-shaped outlined plates of *Asthenosoma* do not imbricate on most of their transverse edges, but the overlap is perfect at the median line of both areas, and a flap of plate must be more or less permanently overlapped or underlapped by another there. The ambulacral plates within the peristome, clearly overlap, and in order that the movement shall be uncontrolled there, the tentacles are associated with pores which are seen upon the plates themselves, and they are not upon the interplate structure.

In both genera of recent Echinothuridæ a special character

is the imperfect calcification of plate areas; the plates are therefore surrounded by soft tissue, and that of one plate is continuous with those of its neighbours, without close suturing.

It must be admitted that the overlap in *Astropyga* is rather an overstrained analogue of that which occurs in *Asthenosoma*; it is slight and persistent in *Astropyga*, and there is no movable soft tissue between the plates.

The interesting work of the Drs. Sarasin upon *Asthenosoma* shows that the longitudinal internal muscles have to do with the movements of the plates. The same authors discovered five large tubular branchiæ (Stewart's organs), passing out below the "compasses" and occupying much vertical space in the ambulacral areas, so that an exaggerated condition of what was formerly considered peculiar to the Cidaridæ prevails. The outer branchiæ were well drawn by A. Agassiz. The jaws and teeth resemble those of *Cidaris*, but the perignathic girdle has ambulacral processes, besides ridges upon the interradia. The want of interradiial peristomial membrane plates is another important character which separates the genera from *Cidaris*; and the ambulacral plates differ entirely in their method of construction from those of that genus, and approach those of the Diadematidæ very slightly. The construction of the apical system is almost anomalous.

It is certainly not correct to state that the alliance of the Echinothuridæ is close with the Palæechinoidea, for there is but slight resemblance between the thick-plated forms of Archæocidaridæ and the group now under consideration. Even those genera of the Perischoechinoidea with bevelled plates which are all thicker than those of the Echinothuridæ, show no evidence of defective calcification nor of the presence of interplate, movable membrane, and the structural characters of *Asthenosoma*, for instance, are scarcely recognized. A. Agassiz has shown that considerable bevelling occurs in some thick-plated spherical Mesozoic and recent Echinoidea, and it does not appear to have been accompanied by movement and flexibility. *Pelanechinus* of the Oolites is the earliest known Echinothurid, and it is more Diadematoid than its successors.

During the Oolitic age there was evidently much variability in the structures of the ambulacra of the original Diadematidæ, and the entrance of the radial plates within the periproctal ring was not uncommon. It appears more reasonable to place the

Echinothuridæ near the Diadematidæ, granting some atavism, than to station them at the end of the Palæechinoidea; the alliance is with the first group, and the descent was probably not through the line of Cidaridæ and Saleniidæ.

The presence of rudimentary internal branchiæ in *Diadema*, according to Ludwig and the Sarasins, is another link with the Diadematidæ. It is proposed to place the Echinothuridæ in a suborder of the Gnathostomes with external branchiæ, the Streptosomata.

With regard to the Family Diadematidæ and its 36 fairly-defined groups, it may be said that the artificial method of classifying with the aid of crenulation and non-crenulation of tubercles gives way to the natural method in which the structure of the ambulacral plates is of primary taxonomic importance. Six former genera become subgenera, and the recognized genera are grouped in 4 very useful Subfamilies (p. 59).

#### I. Suborder Streptosomata (p. 25).

Family ECHINOTHURIDÆ, *Wy. Thomson*, 1873, *Depths of the Sea*, p. 164; 1874, *Phil. Trans. Roy. Soc.* vol. clxiv. pt. 2, p. 730. *A. Agassiz*, 1881, *Report on 'Challenger' Echini*, p. 71. *Ludwig*, 1880, *Zeitschr. für wiss. Zool.* vol. xxxiv. *P. & F. Sarasin*, 1888, *Ergebn. Naturw. Forsch. auf Ceylon*, Bd. i. Heft 3, p. 129.

Moderate to very large, tumid or very depressed, thin, flexible tests. The apical system with the plates usually separated. Coronal plates with membranous edges, with imperfect development of the calcareous element, which is highly and openly reticulate and usually thin. Ambulacral plates simple or compound, with small plates intercalated in the membranous areas, and tentacle-bearing, simple, low, perforated plates, within the peristome, imbricating adorally. Tentacles triserial and heteropodous. Interradial plates variable in shape, variably overlapping and in the opposite direction to the ambulacral plates. External branchiæ small, internal very large. Spheridia may be present. A series of internal longitudinal muscles. Jaws with a small foramen without epiphyses, teeth grooved; perignathic girdle continuous. Spines short, may be sheathed and capped or not at the end, hollow and largely cellular within and with solid wedges externally. Epistromal structures often highly developed.



Subfamily *Pelanechininae*.

Syn. *Pelanechinidae*, Groom, 1887, Quart. Journ. Geol. Soc. vol. xliii. p. 703.

The ambulacral plates compound above the peristome, those near the apex consisting of an adoral primary and six aboral demi-plates; plates near the ambitus large and pentagonal, with the pairs of pores triserial (in three ranks), the demi-plates remotest from the ambulacro-interradial suture, isolated.

Genus *Pelanechinus*.

Subfamily *Echinothurinae*.

Ambulacral plates above the peristome; abactinally with a single large primary associated with two small demi-plates, which are placed in the transverse membranous areas; actinally with a primary plate associated with one or usually two demi-plates, which are situated in or near the ambulacro-interradial sutural line, or remote and isolated, or arrangement confused. Pairs of pores triserial. Plates within the peristome low primaries, each with a pair of pores.

Genus *Echinothuria*.

*Phormosoma*.

*Asthenosoma*.

Subfamily *Pelanechininae* (supra).

Genus PELANECHINUS, *Keeping*, 1878, Quart. Journ. Geol. Soc. vol. xxxiv. p. 924. *Groom*, 1887, *ibid.* vol. xliii. p. 703. (*Adapted.*)

Test large, circular, tumid, depressed, thin, flexible. Apical system wanting.

Ambulacra less than half the width of an interradium, still broad at the peristome, beyond which they are continued. Apically the plates are composed of an adoral primary and two aboral demi-plates, and at the ambitus there are nine components, three of which are primaries, some demi-plates isolated; throughout the poriferous zones to the peristome, the pairs of pores are triserial; beyond the peristome the ambulacral plates are simple, broad, and perforated, the pair of pores in each oblique. A vertical row of plain primary perforated tubercles on either side of the median ambulacral suture.

Interradia with numerous coronal plates which are low, broad, and imbricating more or less, and with four vertical rows of plain primary tubercles at the ambitus, resembling those of the ambulacra, and diminishing in number and size actinally and abactinally, some secondary tubercles.

Peristome large; branchial notches deep. Jaws powerful, with grooved teeth. Spines small, hollow, longitudinally striated. Pedicellariæ small, tridactyle around the peristome, gemmiform orally, large tridactyle aborally.

*Fossil.* Oolite: England.

The above generic definition has been taken mainly from Mr. Groom's admirable description of the solitary species.

#### Subfamily *Echinothurinæ* (p. 41).

Genus ECHINOTHURIA, *S. P. Woodward*, 1863, *Geologist*, vol. vi. pp. 327-330. *Wright*, 1870, *Pal. Soc., Brit. Foss. Ech. Cret. Form.* p. 124.

Test large, plates imbricating, in both areas and in opposite directions. Apical system wanting.

Ambulacra wide at the ambitus, narrower towards the peristome; plates rather high; complete overlap of the adoral edge of one plate upon the corresponding aboral edge of the actinally placed plate, no space left; overlap of the outer edges of the plates by the interradial plate edges. A pair of pores in a primary plate and two pairs in small demi-plates in the position of the adoral suture. Buccal plates imbricating and perforated, ambulacral only. Tubercles small and scanty.

Interradia with larger plates, each in contact throughout its breadth with the plate above and actinally, and overlapping in the contrary direction to the ambulacral plates. Tubercles rare, not large, perforated, the same actinally as dorsally. Spines cylindrical, striated, with a milled ring. Jaws stout. Ornamentation scanty, and similar actinally and dorsally.

*Fossil.* Upper Cretaceous: England.

Genus PHORMOSOMA, *Wy. Thomson*, 1873, *Phil. Trans. Roy. Soc.* vol. clxiv. pt. 2, p. 732 (1874). *A. Agassiz*, 1881, *Report on 'Challenger' Echini*, p. 91; *Report on 'Blake' Exped. Echini*, 1883, p. 35.

Test small to large, thin, more or less flexible, tumid or depressed dorsally, flat actinally, circular or polygonal in ambital

outline; the structures of the abactinal and actinal surfaces differing. Plates numerous, thin, and surrounded by membrane, imbricating more or less.

Apical system star-shaped, large; plates united by membrane; basals projecting into the interradial median line, separated from the radials by periproctal plates and membrane; madreporite large. Periproct with small spine-bearing plates.

Ambulacra straight, broad; plates low abactinally, high and complicated actinally; a pair of pores in each plate, and a pair in each of the two small accessory plates along the adoral or the ambulacro-interradial suture; buccal plates continuous with those of the ambulacra, low, broad, pore-penetrated, overlapping. Primary tubercles of the interporiferous areas few, small, larger at the margin, more numerous actinally, perforate, scrobiculate; plates with granules.

Interradia with numerous low and broad plates, partly but broadly overlapping from below upwards, or connected all along the transverse sutures by membrane. Tubercles larger than in the ambulacra, smaller and most numerous actinally.

Peristome moderate, branchial incisions small, external branchiæ distinct. Perignathic girdle slender. Spines short, longest and most numerous actinally, where some are capped with a hoof-shaped process, others club-shaped or like long and short needles, striated and cylindrical in section, may be sheathed. Pedicellariæ some long and blunt-headed, others with very open valves, and many tridactyle and blunt-headed. Actinal tentacles disciferous, and the abactinal are pointed and branchial.

The plates, especially of the ambulacra, often seem to be split up in a remarkable manner. Spheridia may exist.

*Recent.* N. Atlantic to Azores; Caribbean Sea, and to the N., Japan, Philippines, Sandwich Islands, Low Archipelago, E. Pacific, Australia, Juan Fernandez to Chili. 120 to 2750 fathoms.

Genus *ASTHENOSOMA*, Grube, 1868, *Jahresb. d. Schles. Ges. f. Vaterl. Cult.* p. 42. *A. Agassiz*, 1872, *Revision*, p. 272; *Ech. of 'Blake' Exped.* 1883, p. 29. *Ludwig*, 1880, *Zeits. f. wiss. Zool.* vol. xxxiv. *P. & F. Sarasin*, 1888, *Erg. Nat. For. auf Ceylon*, Bd. i. Heft 3, p. 129.

*Syn. Calveria*, Wy. Thomson, 1873, *Phil. Trans. Roy. Soc.* vol. clxiv. pt. 2, p. 737.

Test moderate to very large, tumid at the circular or slightly polygonal ambitus, swollen, subhemispherical or depressed abactinally, flat actinally; more or less flexible. The calcareous deposits of the plates limited, the edges of the plates membranous.

Apical system central, polygonal, projecting; the plates separated by membrane, and some anal plates intervening between the basal and radial plates. Periproct small; anus projecting.

Ambulacra straight, broad at the ambitus; plates very numerous and much bent vertically, overlapping from above actinally, and overlapped by the ends of the interradiial plates; a pair of pores in each plate, and two small plates in the adoral sutural membrane, each with a pair of pores. Plates continued from the peristomial edge to the mouth, imbricating, each plate broad, low, and pore-pierced. Small primary perforate, non-crenulate, areolated primary tubercles, in two or more vertical rows.

Interradia with numerous broad, low, pistol-shaped plates, united by membrane along the transverse edges, and expanded and overlapping at the median line; overlap in the opposite direction to that of the ambulacra; two or more vertical rows of primary tubercles resembling those of the ambulacra.

Peristome with small branchial incisions; internal branchiæ very large and five in number, the external branchiæ small; lower tentacles with prehensile discs, the abactinal pointed and branchial. Perignathic girdle weak, but with a decided arch between continuous processes.

Jaws with a small foramen; teeth grooved. Spines delicate, hollow, fenestrated, longitudinally striated and ridged, variable in length, but never very long; the secondary spines small, sharp and numerous, pointed, some sheathed. Pedicellariæ numerous, various, tridactyle, four-valved, some sharp and others blunt-ended.

*Recent.* N. Atlantic to coast of Portugal, Florida, Caribbean Sea, China Seas, Java, Philippines, Indian Archipelago, Ceylon, Fiji, New Zealand. From 100 to 450 fathoms.

III.

The Suborder Stereosomata and its Families. The Family Saleniidæ and its Genera. Family Hemicidaridæ and its Genera. Family Diadematiidæ; its Subfamilies and Genera. Genus incertæ sedis. Family Cyphosomidæ and Genera. Family Arbaciidæ and Genera. Family Temnopleuridæ; Subfamilies and Genera.

II. ORDER.

II. Suborder Stereosomata (p. 25).

- I. Family SALENIIDÆ.
- II. „ HEMICIDARIDÆ.
- III. „ ASPIDODIADEMATIDÆ.
- IV. „ DIAEMATIDÆ.
- V. „ CYPHOSOMIDÆ.
- VI. „ ARBACIIDÆ.
- VII. „ TEMNOPLEURIDÆ.
- VIII. „ ECHINOMETRIDÆ.
- IX. „ ECHINIDÆ.

I. Family SALENIIDÆ, *Duncan and Sladen*, 1887, *Ann. & Mag. Nat. Hist.* ser. 5, vol. xix. p. 117.

Regular ectobranchiate gnathostomes, with a persistent dorso-central plate or plates; madreporite in the right anterior basal plate. Ambulacra narrow, the plates numerous, simple low primaries, rarely in compound plates actinally. Interradial plates few and tubercles large. Peristome with branchial incisions and external branchiæ. Perignathic girdle with interradian ridges and ambulacral processes united or not. Jaws with the foramina of the pyramids unarched by epiphyses; teeth with a keel. Spheridia present. Spines very variable, cellular with a solid superficies.

Division I.

Genus *Peltastes*.

Syn. *Hyposalenia*; *Pseudosalenia*; *Poropeltis*.

Subgenus *Goniophorus*.

Genus *Salenia*.

Subgenus *Heterosalenia*.

Division II.

Genus *Acrosalenia*.

*Division I.*

Ambulacral plates simple.

Genus PELTASTES, *Agassiz*, 1838, *Monogr. d'Éch. viv. et foss.* livr. i. p. 27, pl. v. (non *Desor*, 1858, *Synopsis*, p. 145). *Duncan & Sladen*, 1887, *Ann. & Mag. Nat. Hist.* ser. 5, vol. xix. pp. 129–132. (*Amended.*)

Syn. *Pseudosalenia*, Cotteau, 1859, Rev. et Mag. de Zool. vol. xi. sér. 2, p. 215. *Hyposalenia*, Desor, 1858, Synopsis, p. 147. *Poropeltis*, Quenst., 1858 and 1872-5, Petr. Deutschl. tab. 69.

Test small, circular in outline, tumid at the ambitus, depressed and slightly tumid abactinally, or tall, and with a part of the apical system projecting, actinally rather flatly curved.

Apical system large, raised slightly, and part of it usually projecting, with large basals and small radials; a small dorso-central plate, in the long axis of the system, united to the lateral basals, but not touching the posterior basal; incurved posteriorly for the anterior margin of the anus. Radials large, not within the ring. Periproct posterior and bounded in front by the dorso-central plate, and posteriorly and laterally by the basals 4, 5, and 1. The sutures of the disk often grooved, marked with depressions and the prolongation of the ornamentation of the basal and dorso-central plates; these plates have grooves and eminences often radiate in arrangement, margins of the basals often variously curved and notched.

Ambulacra narrow, straight or slightly flexuous, with small primary tubercles near the poriferous zone; plates low primaries only. Interradia with large primary tubercles diminishing in size above and below the ambitus, crenulate or not and imperforate.

Peristome small, rather reentering, slightly incised. Perignathic girdle with low broad ridges and slender unarched processes.

*Fossil.* Cretaceous: England. Upper Jurassic and Cretaceous: Europe. Cretaceous: N. Africa.

Subgenus GONIOPHORUS (genus), *Agassiz*, 1838, *Monogr. d'Éch. viv. et foss.* livr. i. p. 30. *Cotteau*, 1861, *Bull. Soc. Géol. France*, sér. 2, vol. xviii. p. 624. *Duncan and Sladen*, 1887, *Ann. & Mag. Nat. Hist.* vol. xix. pp. 131-132.

Test small, swollen, subspheroidal, with large peristome, few interradiial primaries, upon high plates. Apical disk pentagonal, with five large basals and five small radials, ornamented with linear, raised and straight keels which are not on the lines of the sutures; dorso-central plate large, the periproct posterior to it and elongate transversely. Pits for spheridia large in the narrow ambulacra actinally.

*Fossil.* Upper Greensand: England, Europe, N. Africa.

Genus SALENIA, *Gray*, 1835, *Proc. Zool. Soc. Lond.* pt. 3, p. 58.

*L. Agassiz*, 1838, *Monogr. d'Éch. viv. & foss.* livr. i. p. 6.

*A. Agassiz*, 1874, *Revision of the Echini*, p. 258; 1883, *Blake, Ech.* p. 13. *Duncan & Sladen*, 1887, *Ann. & Mag. Nat. Hist.* ser. 5, vol. xix. p. 132. (*Amended.*)

Test small, subglobose or depressed. Apical system larger than the peristome, more or less raised. The dorso-central plate more or less geometrical, imperfect, and eroded at the right posterior angle by the periproctal ring, in contact with all the basals. Apical plates ornamented with radiating grooves and ridges. Radial plates large, with the pore in the adoral edge, one plate may or may not enter the periproctal ring. Periproct large, with a plated membrane pierced by the anal opening.

Ambulacra narrow, with two rows of small primary tubercles and granules; plates all simple primaries, crowding rare near the peristome. Pairs of pores in simple vertical series; tentacles sub-homoiopodous. Interradia with large primaries. Tubercles of both areas crenulate, or some plain, and imperforate.

Peristome with cuts for the external branchiæ, with a membrane plated or not. Perignathic girdle with broad ridges and slender ununited processes; jaws with the foramen of the pyramid small, unarched; teeth with a keel. Spines of primaries long, slender, variable in ornamentation; small spines club- and wedge-shaped and flat. Pedicellariæ of the three kinds; epistroma often much developed. Spheridia exist.

*Fossil.* Cretaceous: England, Europe, Asia, North and West Africa. Eocene: Europe, Asia. Miocene: Australia.

*Recent.* Caribbean Sea, both of the great Oceans, Japanese Sea. Depth from 60 to 1700 fathoms.

Subgenus HETEROSALENIA (genus), *Cotteau*, 1861, *Pal. Franç., Terr. Crét.* p. 96, pl. 1022. *Duncan & Sladen*, 1887, *Ann. & Mag. Nat. Hist.* ser. 5, vol. xix. p. 132.

The primary tubercles are perforated.

*Fossil.* Cretaceous: Europe.

### *Division II.*

In the second division of the genera of the Family the ambulacral plates are compound at a short distance from the apical system, and the pairs of pores are crowded near the peristome.

Genus ACROSALENIA, *Agassiz*, 1840, *Éch. foss. de la Suisse*, pt. 2, p. 38. *Duncan & Sladen*, 1887, *Ann. & Mag. Nat. Hist.* ser. 5, vol. xix. p. 128.

Test moderate in size, depressed, tumid at the circular and rarely pentagonal ambitus, rounded above, flatter actinally.

Apical system rather large, four anterior basals large, and the posterior smallest and differing in shape. A dorso-central plate in the antero-posterior axis of the system, in contact with the four larger basals and anterior to the periproct. Supplementary plates to the dorso-central may occur. Posterior radial plates enter the ring of the periproct, rarely a radial separating the antero-lateral and postero-lateral basals. Periproct large and posterior.

Ambulacra narrow, with primary plates near the apical system and with compound plates near the ambitus and actinally. Compound plates of united primaries with rare demi-plates, except near the peristome. Pairs crowded and biserial near the peristome, from the presence of demi-plates. Tubercles of the interradia largest, perforate and crenulate; those of the ambulacra much smaller, or only as large granules.

Peristome large, decagonal, with well-developed branchial grooves with raised edges. Perignathic girdle with low ridges and slender processes sometimes uniting. Spines large and small, the former striated longitudinally, or plain, and often not quite circular in transverse section; smaller spines striated.

*Fossil.* Lias and Oolites: England and Europe. Lower Cretaceous: N. Africa.

## II. Family HEMICIDARIDÆ, *Wright*, 1857, *Pal. Soc., Ech. Ool. Form.* p. 68. (*Amended.*)

Regular ectobranchiate gnathostomes with the test thick, more or less spheroidal, depressed or tall or subconical. Ambulacra increasing in width actinally; primary tubercles well developed, but smaller than those of the interradia, extending or not throughout in two vertical rows; pairs of pores in arcs actinally where the plates are compound. Interradia large, plates few; tubercles very large at the ambitus, variously sized actinally and dorsally, and may be obsolete there. Scrobicules often coalescing. Peristome decagonal, ambulacral lips large, branchial incisions well developed. Perignathic girdle with interradian ridges and united



ambulacral processes. Jaws large, foramen large, without epiphyses; teeth grooved. Spines often large, variable, and usually solid.

Genus *Hemicidaris*.

Subgenus *Hemidiadema*.

„ *Hypodiadema*.

„ *Pseudocidaris*.

„ *Asterocidaris*.

Genus *Acrocidaris*.

Subgenus *Acropeltis*.

Genus *Goniopygus*.

„ *Circopeltis*.

„ *Cidaropsis*.

„ *Glypticus*.

Genus incertæ sedis : *Leptocidaris*, Quenst.

Genus HEMICIDARIS, *Agassiz*, 1840, *Éch. Foss. de la Suisse*, pt. ii. p. 42. *Desor*, 1858, *Synopsis*, p. 50. *Duncan*, 1885, *Quart. Journ. Geol. Soc.* vol. xli. p. 436. (*Amended*.)

Syn. *Tiaris*, Quenst.; *Hemipygus*, Étallon (immature).

Test of moderate size, spheroidal, tall, tumid at and above the ambitus, flattish and often broadest actinally.

Apical system small, either with large united basal plates (or some or all radial plates enter the periproctal ring\*).

Ambulacra narrow, enlarging near the ambitus, projecting or not; the plates a multitude of small low primaries near the apical system, succeeded by compound plates which may be formed by two to four constituents, their arrangement partly “Diadem- atoid,” but with additional primary or demi-plates, placed abactinally to the large tuberculous primary plate. Pairs of pores simple abactinally, in arcs near the large tubercles, and crowded near the peristome. Tubercles in two vertical rows, perforate and crenulate, large to varying distances above the ambitus, and then diminishing in size or replaced by granules.

Interradia broad, with but few high coronal plates, with two vertical rows of large, projecting, perforate and crenulated primary tubercles, larger than those of the ambulacra. Scrobicules usually contiguous and incomplete; secondary tubercles and granules.

Peristome large and the branchial incisions well developed. Pyramids of the jaws with a large incomplete foramen; teeth

\* Very rare, or probably in subgeneric groups only.

grooved. Spines large, some needle-shaped, others club-shaped and longer than the test's diameter, some knob-ended, others forked, longitudinally striated, some marked across.

*Fossil.* Zechstein, Alpine Trias, Lias, Oolites, Cretaceous : Europe. Oolites : England. Jurassic, Tithonian, and Cretaceous : N. Africa.

This important genus has several fairly well marked subgenera (formerly genera). It appears that the genus *Hemipygus*, Étallon, 1850, *Études Pal. Haut-Jura*, suppl. p. 4, relates to small, young, and immature *Hemipygi*. As is usual in Echinoidea only 4 millim. in height and 8 millim. broad, the apical system is exaggerated in size and the genital perforations are variable. It is placed as a synonym of *Hemicidaris*.

Subgenus HEMIDIADEMA (genus), *Agassiz*, 1840, *Ech. Suisse*, pt. ii. p. 47. *Étallon*, 1859, *Lethæa Brunt.* p. 326.

The tubercles of the ambulacra large and few in number below the ambitus, alternating distinctly.

*Fossil.* Oolites and Cretaceous : Europe.

*H. stramonium*, Agass., is the type ; but *H. rugosum* does not belong to the genus, it is a *Glyphocyphus*, Haime.

Many of the species of the next subgenus have been determined from immature specimens ; this is especially the case with the St.-Cassian forms.

Subgenus HYPODIADEMA (genus), *Desor*, 1858 (pars), *Synopsis*, p. 61. *Laube*, 1865, *Denks. Akad. Wiss. Wien*, vol. xv. p. 295. *Zittel*, 1879, *Handb. d. Pal.* p. 501.

Ambulacra narrow, straight, with two rows of small, crenulate, perforate primaries (?), nearly maintaining their size throughout, diminishing but slightly abactinally. Interradia with large primary tubercles, in two vertical rows extending to the apex ; plates granular beyond the scrobicules.

Peristome and the branchial incisions small. Spines cylindrical and smooth.

*Fossil.* Oolite : England ? Trias, Oolites, and Cretaceous : Europe.

The Cretaceous species have variable branchial incisions, and in one the primary interradian tubercles do not reach the apex.

Subgenus PSEUDOCIDARIS, *Étallon* (genus), 1859, *Lethæa Brunt.* p. 333. *Cotteau*, 1882, *Bull. Soc. Zool. de France*, vol. vii. p. 1. *De Loriol*, 1887, *Rec. Zool. Suisse*, vol. iv. p. 336, pl. xv. figs. 2—"b."

Ambulacra very undulating abactinally, narrow, with primary tubercles only near the peristome, granules elsewhere. Interradia broad, with few coronal plates, and two vertical rows of large primary tubercles, distant. Spines large, massive, cylindroid or fusiform, or pear-shaped, striated longitudinally or granular.

*Fossil.* Oolite and Cretaceous : Europe, N. Africa, Mexico.

The genus *Asterocidaris*, *Cotteau*, 1859, has all the characters of *Hemicidaris*, and it appears that the existence of star-shaped or triangular bare spaces in the median interrarial areas near the projecting basal plates is not of generic importance. *Asterocidaris* should be placed as a subgenus of *Hemicidaris*, with the following characters :—

Subgenus ASTEROCIDARIS, *Cotteau*, 1859 (genus), *Rev. et Mag. de Zool.* sér. 2, vol. xi. p. 159.

Apical system large, with basal plates projecting adorally into a bare median interrarial space ; interrarial plates ten or less in number in each vertical series.

*Fossil.* Europe.

Genus ACROCIDARIS, *Agassiz*, 1840, *Ech. Foss. de la Suisse*, pt. ii. p. 10. *Desor*, 1858, *Synopsis*, p. 83.

Test large, tumid at the ambitus, and subconical or spheroidal dorsally, flat actinally.

Apical system small, some or all of the basal plates with a large perforate tubercle, the madreporite large. Periproct large.

Ambulacra straight, broad at the ambitus, with two vertical rows of large perforated primary tubercles, slightly smaller than those of the interradia, and extending to the apex ; pairs of pores uniserial and in simple series near the apex, in arcs of from four to seven pairs near the larger tubercles, crowded and polyserial actinally ; plates "diadematoïd," with some additional components ; sutural lines as grooves on the flanks of the tubercles.

Interradia with two vertical rows of large primary tubercles, only the largest being perforate and crenulated.

Peristome large, branchial incisions well developed. Spines cylindrical, smooth or finely striated, often tricarinate at the top.  
*Fossil.* Oolitic: Europe and N. Africa. Cretaceous: Europe.

Subgenus ACROPELTIS, *Agass.* (genus), 1840, *Catal. Syst. Ectyp.* p. 19; *Éch. Foss. de la Suisse*, pt. ii. p. 27.

The primary tubercles of all the areas are imperforate and uncrenulate; the largest tubercles are actinal.

*Fossil.* Oolite: Europe.

The type of *A. concinna*, Merian, figured by Cotteau, 1861, *Rev. et Mag. de Zool.* vol. xiii. p. 76, is immature, it being only 1 millim. high and 2 millim. broad. Hence the large dorso-central system.

Genus GONIOPYGUS, *Agass.* 1838, *Monogr. d'Éch. viv. et foss.* livr. i. p. 19. *De Loriol*, 1887, *Faune Crét. du Portug.*, *Éch.* fasc. i. p. 55.

Test small, depressed, hemispherical dorsally, circular in outline at the tumid ambitus, broader than high.

Apical system large and stout, the prominent basal plates close, polygonal, and angular adorally or almost square; sutures dentated, perforated, or otherwise ornamented; periproctal edges in ridges and notched; periproct small, triangular or square, and may be circular in outline; radial plates remote from the periproct, pentagonal and wide actinally, variously ornamented.

Ambulacra narrow, with two vertical rows of primary plain tubercles, smaller than those of the interradia, which are large, plain, and in two vertical rows. Pairs of pores in simple primary plates abactinally, but near the tubercles of the actinal surface the plates are triple compounds, there being an adoral demi-plate, a median primary, large, and an aboral primary; the sutures are convex towards the tubercle.

Peristome very large, with small branchial incisions. Spines small, club-shaped, striated or not.

*Fossil.* Cretaceous: Europe, N. Africa, Asia. Eocene: Europe.

The genus *Circopeltis* originated with M. Pomel, 1883, but his definition was not a positive one; he compared it with *Leiosoma*. M. de Loriol has, however, shown that the genus is not related to *Leiosoma* but to *Goniopygus*.

Genus *CIRCOPELTIS*, Pomel, 1883, *Thèses Class. Méthod. Éch. (Alger)*, p. 89. De Loriol, 1887, *Faun. Crét. du Portug., Éch.* fasc. i. p. 55, pl. ix. fig. 7.

Test small, subhemispherical, depressed dorsally, flat actinally. Interradial plates few (8-9).

Apical system solid, with or without radial plates entering the periproctal ring; periproct large and subcircular.

Ambulacra straight, expanding near the large tubercles, broad at the peristome, the interporiferous area with primary tubercles in two vertical rows, large at the ambitus, and smaller actinally, and smallest and distant abactinally, all are plain; poriferous zones with uniserial pairs of pores abactinally, in slight arcs near the large tubercles, and slightly crowded actinally; plates low, broad, simple primaries abactinally, compound at the ambitus and actinally, the adoral component a demi-plate and its pair of pores much nearer the median line than the other pairs, excluded from the ambulacro-interradial suture. The other components long; low primaries with an occasional demi-plate.

Interradia with two vertical rows of plain primary tubercles, largest at the ambitus; rows of secondary tubercles and granules.

Peristome moderate, with branchial incisions.

*Fossil.* Cretaceous: Europe, N. Africa (?).

The compound ambulacral plates are not without an affinity with those of the recent *Aspidodiadema*, A. Agass.

Genus *CIDAROPSIS*, Cotteau, 1860 (reference not to be found).

1882, *Pal. Franç., Terr. Jura*, livr. lvi. p. 433, pls. 376, 377.

Test moderate and rather small in size, swollen above and almost flat below, circular in outline at the ambitus.

Apical system solid and moderately developed.

Ambulacra subflexuous abactinally, enlarging at the ambitus, having small primary tubercles actinally which are smaller than those of the interradia, perforate and crenulate. Towards the apex the tubercles are replaced by granules. Poriferous zones undulating, with simple pores, close, and they multiply near the peristome.

Interradia broad, with few plates and two rows of large primary tubercles, perforate, non-crenulate and distant, with projecting scrobicules.

Peristome large, subdecagonal, and with large branchial incisions. Periproct subcircular. Spines large and glandiform.

*Fossil.* Europe: Jurassic formation.

Cotteau places the genus close to *Hemipedina*; but it appears to be nearer *Hemicidaris*.

Genus GLYPTICUS, *Agassiz*, 1840, *Éch. Foss. de la Suisse*, pt. ii. p. 95. *Desor*, 1858, *Synopsis*, p. 95. *Cotteau*, 1880-85, *Pal. Franç.*, *Éch. Terr. Jura*, pl. 418.

Test moderate in size, thick, subhemispherical, flat actinally.

Apical system large, slightly raised, the basals in contact, stout, sculptured; the sutures depressed, pitted more or less; the radial plates large, between the outer part of basals as broad as they are, pentagonal, broad and re-enteringly curved adorally. Periproct elliptical, or pentagonal with a raised rim, small.

Ambulacra straight, narrow, except at the peristome, where the poriferous zones are expanded. Poriferous zones straight, narrow, sunken; pairs in compound plates usually triplets, polyserial at the peristome; two vertical rows of small, smooth, primary tubercles, the mamelons confounded with the bosses, imperforate and non-crenulate, pass to the apex from the peristome, close to the poriferous zones; or the tubercles may be replaced above the ambitus by elongate smooth elevations of the plates placed irregularly or not. Epistroma much developed.

Interradia with large primaries resembling those of the ambulacra at the ambitus and actinally, but with warty or irregularly elongate elevations, with or without secondary tubercles, abactinally; granules and secondary tubercles exist.

Peristome large, decagonal, often deformed and longer in the antero-posterior direction than across, the branchial incisions well developed, and a notch at the ambulacral median line also.

*Fossil.* Oolite: England, Europe, and N. Africa.

*Incertæ sedis.*

Genus LEPTOCIDARIS, *Quenstedt*, 1858, *Der Jura*, pl. 90. fig. 10 ;  
and 1874, *Petr. Deutsch.* p. 232, tab. 69. figs. 71.

Test spheroidal; the ambulacra moderate and straight; the pores are in arcs of triple pairs, and each compound plate is large, higher than an interradial plate, and alternately broad and narrow; small perforated primary tubercles on alternate plates, or more distant.

The ambulacral plates have each a large adoral primary component, which carries the tubercle and a middle and aboral demi-plate.

Interradial plates low and broad.

*Fossil.* Jurassic: Europe.

The description is taken from that mine of wealth, *Quenstedt's* *Petrefact. Deutschlands*, Leipzig, 1874. The type is *L. triceps*, *Quenst.*

In the Report on the Echini of the 'Challenger' and 'Blake' Expeditions A. Agassiz described species of *Aspidodiadema*, a genus which he defined comparatively rather than positively. He gave his usual careful opinions regarding the affinities of the genus, and noticed how it links together the Cidaridæ and Diadematidæ. The descriptions of the species and the figures which illustrate them are so clear and definite that all the taxonomic difficulties surrounding them are really seized at a glance. A palæontologist would hardly hesitate to add *Hemicidaris* to the list of allied genera; and any naturalist who has studied the ancient and modern faunas would say that there is a wonderful union of almost excessive modern characters, and others characteristic of deep-sea dwellers, combined with the Hemicidaridean, accompanied by a Cidaroid ambulacral structure.

The paucity of interradial plates, each with a large perforate and crenulate tubercle, associated with branchial peristomial incisions, and without imbricating ambulacral and interradial buccal plates, there being only ten huge simple buccal plates, the ambulacral plates being few simple primaries, with or without large primary tubercles, may be said to be a jumble of characters which will prevent the forms being classified with the families Hemicidaridæ and Diadematidæ. It is proposed to form a family for the genus.

## III. Family ASPIDODIADEMATIDÆ.

Diadematoidea with spheroidal tests, having a large, narrow, ringed apical system formed by broad basals and broad intervening radial plates; having few interradianal plates, each with a large primary perforate and crenulate tubercle; straight ambulacra with numerous low primary plates with or without primary tubercles; pairs of pores, one in each plate in straight vertical series. Peristome incised; branchiæ bifid, and with ten very large buccal plates; tentacles heteropodous. Spines hollow and striated, verticillate.

The generic definition given by A. Agassiz of *Aspidodiadema* is very comparative, and we therefore venture to give a positive diagnosis founded upon the study of the species which have been so admirably described and figured in the Reports on the 'Challenger' and 'Blake' Echinoidea\*.

Genus ASPIDODIADEMA, A. Agassiz, 1879, *Proc. Amer. Acad.* vol. xiv. p. 199; 1881, *Report on 'Challenger' Echini*, p. 64; 1883, *Report on 'Blake' Echini*, p. 24.

Syn. *Plesiodiadema*, Pomel, 1883, non Duncan. (*Adapted.*)

Test moderately large, tall, spheroidal, thin; interradianal coronal plates few in number.

Apical system large, the narrow ring of plates composed of broad basals and of wide intervening included radial plates; the periproct large, the membrane with few or numerous radiating plates, some united and reaching from the ring to the anus, which may be tubular.

Ambulacra broad, with a few large primary perforated and crenulated tubercles sometimes reaching above the ambitus, and with smaller tubercles or granules abactinally, or with only small tubercles and loose granules throughout. The pairs of pores are numerous, in simple vertical series, and the plates are simple and low broad primaries. Tentacles heteropodous.

The interradiana have two vertical rows of large primary perfo-

\* The fact that *A. microtuberculatum*, A. Ag., has small tubercles on its ambulacra must not be forgotten; but at the same time it must be remembered that all the other generic characters are the same as those of the other species. It is hardly worth while, therefore, to disturb the genus, as has been attempted by a naturalist who has not seen the forms.



rated and crenulated tubercles, and with expanded bases, largest at and above the ambitus.

Peristome smaller than the apical system, with small branchial incisions and bifid branchiæ; ten very large spined buccal plates. Teeth grooved. Spheridia large and extending high up on the ambulacra. Spines hollow, verticillate, straight and curved, some large and very long, others similar and small. Pedicellariæ various, some with large glands upon the stem.

*Recent.* Caribbean Sea, 95–1200 fms.; N. part of the South Atlantic, and also the Chili coast, 356–2225 fms.; Philippine Sea, 100–1700 fms.

The Family Diadematidæ was well formulated by Cotteau and Wright, and the arrangement of the genera, by the existence or not of crenulation and perforation of the primary tubercles, has been very popular and useful; but it is too artificial, for the physiological importance of the superficial structures of the tubercles is exceedingly small. Careful consideration proves that many genera have been placed in the Family which can hardly remain, and they have now found places in the Families of Hemicidaridæ, Temnopleuridæ, Arbaciidæ, and Cyphosomatidæ.

Many genera have been introduced since Cotteau founded the Family, and it is now fairly homogeneous, if they are arranged with their fellows on the principle of the structures of the ambulacra being considered of primary taxonomic importance. It is the group of genera which is characterized by having numerous small tubercles placed actinally and at the ambitus, but then ceasing more or less, which has given much trouble. Such genera are *Codiopsis*, *Gymnodiadema*, *Plistophyma*, and *Polycyphus*. Again, *Orthopsis* and its allies are difficult to classify upon the old lines of the value of crenulation and perforation. It may be stated, as a general truth, that if these genera be classified by the ornamentation of the tubercles, groups possessing very diverse ambulacra will be associated.

The Family separates by the new method into subfamilies.

A most unfortunate decision of Desor's has made palæontologists and students of the recent fauna look upon some of the most important species of one genus in a very different light. Desor introduced the genus *Pseudodiadema* to take the place of fossil *Diademæ*. The only distinctions between the recent genus

and the one founded by Desor, which in the first instance was called by the same name as the recent forms (*Diadema* by Gray), are that there is no verticillation of the longitudinally striated spines of *Pseudodiadema*, and the spines are solid in the fossil, hollow in the recent form. These are possibly specific characters at the most, and hence one of the first steps in a revision must be the elimination of *Pseudodiadema*, with its host of species.

#### IV. Family DIADEMATIDÆ\*.

Regular ectobranchiate gnathostomes, with or without rudiments of internal branchiæ, with highly ornamented, tumid, depressed, or spheroidal tests; with a well-developed dorso-central system, often with a tubular anal orifice; with the madreporite in the right anterior basal.

Ambulacra moderately broad or narrow, straight, flush or tumid, with vertical rows of primary tubercles resembling the interradial but usually smaller; pairs of pores either in simple series, or in arcs, or in two or more vertical series; the plates compound near the ambitus and actinally, low and numerous; the median component carrying the tubercle and reaching the median line, and therefore a large primary plate, and the adoral and aboral plates of the compound low, broad primaries, smaller than the median plate and having their sutural lines curved towards the tubercle of the median component; demi-plates rarely exist.

Interradia broad, with numerous low plates, with vertical rows of primary tubercles, and sometimes with more than one horizontal row of them on a plate; vertical rows varying in number, diminishing dorsally; tubercles resembling those of the ambulacra, but usually larger.

Peristome large, polygonal, with branchial incisions. Perignathic girdle continuous; processes arched and the ridges low. Jaws without a closed pyramidal foramen; teeth grooved. Tentacles heteropodous. Spheridia present. Spines variable, short or long, hollow, striated and grooved longitudinally, verticillate or not, (solid from fossilization).

\* The definition is an amendment of Gray, 1835; Peters, *Abhandl. d. königl. Akad. d. Wiss. Berlin*, read 1853, published 1855, p. 106; A. Agassiz, 1874. For morphology see *Quart. Journ. Geol. Soc.* 1885, p. 419, *Journ. Linn. Soc.* vol. xix. 1885, pp. 95 and 201. Also P. and F. Sarasin, *Ergebn. Naturw. Forsch. auf Ceylon*, 1884-6, published 1887, Bd. i. Heft 1, pp. 1-17.

I. Subfamily *Diadematinæ*. Ambulacral plates compound, near the ambitus; the pairs of pores in simple vertical series or in arcs of threes.

I. Genus *Diadema* (syn. *Pseudodiadema*).

Subgenera *Centrostephanus*, *Microdiadema*, *Diademopsis*,  
*Hemipedina*, *Echinodiadema*.

II. Genus *Placodiadema* (syn. *Plesiadiadema*).

III. „ *Heterodiadema*.

IV. „ *Codiopsis*.

V. „ *Pleurodiadema*.

VI. „ *Magnosia*.

VII. „ *Cottaldia*.

II. Subfamily *Diplopodiinæ*. Ambulacral plates compound; pairs of pores biserial.

I. Genus *Diplopodia*.

II. „ *Pedinopsis*.

III. „ *Acanthechinus*.

IV. „ *Phymechinus*.

V. „ *Asteropsis*.

VI. „ *Diplotagma*.

VII. „ *Micropyga*.

VIII. „ *Plistophyma*.

III. Subfamily *Pedininæ*. Ambulacral plates compound; pairs of pores triserial.

I. Genus *Pedina*.

Subgenus *Pseudopedina*.

II. Genus *Echinopedina*.

III. „ *Stomechinus*.

IV. „ *Micropedina*.

V. „ *Heterocidaris*.

VI. „ *Echinothrix*.

VII. „ *Astropyga*.

VIII. „ *Polycyphus*.

IX. „ *Codechinus*.

IV. Subfamily *Orthopsinæ*. Ambulacra with simple primary plates; pairs of pores in simple series.

I. Genus *Orthopsis*.

II. „ *Eodiadema*.

III. „ *Peronia*.

IV. „ *Echinopsis*.

V. „ *Gymnodiadema*.

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Genus incertæ sedis. *Progonechinus*.

I. Subfamily *Diadematinæ* (p. 59).

Genus *DIADEMA*, Schynvoet, 1711, *Thes. Imag. Pisc. &c.* p. 2, pl. xiv. Gray, 1825, *Ann. Phil.* vol. xxvi. p. 426. Peters, 1853, *Abhandl. k. Akad. Wiss. Berlin* (1854), p. 107. Bölsche, 1865, *Archiv für Naturg.* vol. xxxi. p. 325. A. Agass. 1874, *Revision*, p. 274. Duncan & Sladen, 1885, *Journ. Linn. Soc. (Zool.)*, vol. xix. p. 95. Lovén, 1887, *On Species of Ech. desc. by Linnæus, Bihang till K. Svenska Vet.-Akad. Handl.* Bd. xiii. Afd. iv. No. 5, pp. 125-137. Sarasin, P. & F., 1887, *Ergebn. Naturw. Forsch. auf Ceylon*, Bd. i. Heft 1, pp. 1-17.

Syn. *Pseudodiadema*, Desor; *Tetragramma*, Agass.; *Hebertia*, Mich.

Test thin, moderate in size, circular or slightly polygonal in tumid marginal outline, wider than high, rather depressed.

Apical system sunken or not, large; basal plates large, with a long outer angle and large duct-perforation; radial plates small and some may enter the periproctal ring. Periproct large, with a thin membrane furnished with a few plates near the ring. Anal orifice at the end of a tube.

Ambulacra straight, narrow, often projecting; pairs of pores in simple series in arcs; plates compound, each with a middle broad primary component carrying a tubercle and occupying much of the median sutural edge, having a long low primary above and below and occupying but little of the median sutural edge, the edges of these plates curved, convexity towards the base of the tubercle on the middle plate. Two vertical rows of small, primary, crenulate and perforate tubercles extending from peristome to apex.

Interradia with a bare median space near the apex or not; coronal plates long and low. Primary tubercles in two or more rows, resembling those of the ambulacra in structure, but larger; secondary tubercles and granules on the flanks of the scrobicules.

Peristome large, decagonal; branchial incisions with "tags." Actinal membrane thin, but slightly plated. Perignathic girdle with well-developed ridges; processes united and rather tall, a projection of the test beyond the ridges into the peristome. Jaws large; pyramids with a tall foramen open above; teeth grooved. Eye-spots numerous. Spines long, hollow, closely verticillate, striated longitudinally, milled ring prominent.

*Fossil.* Lias, Oolites, Cretaceous: England, Europe, N. Africa, Egypt, Asia, N. America. Eocene: Europe.

*Recent.* Caribbean Sea, Cape Verd, Indian Ocean, Red Sea, Japan, Pacific Ocean, W. coast of Central America.

Subgenus *CENTROSTEPHANUS*, *Peters*, 1853 (genus), *Abh. d. k. Akad. d. Wiss. Berlin*, 1854, pub. 1855, p. 109 (note). *A. Agass.* 1874, *Revision*, p. 409. *Duncan*, 1885, *Journ. Linn. Soc. (Zool.)*, vol. xix. p. 110.

Syn. *Echinodiadema*, *Verr.*; *Trichodiadema*, *A. Agass.*

Test thick, large or moderate, globular or depressed, circular at the tumid ambitus.

Apical system with basal plates separated by small, rectangular periproctal plates, and by radial plates also. Periproct with minute plates. Anal opening small.

Ambulacra with two rows of tubercles and the plates as in *Diadema*, but the poriferous zones may be sunken.

Interradia twice as broad as the ambulacra; four vertical rows of perforate and crenulate tubercles, two rows being more prominent than the others, all subequal; median space ill-defined.

Actinal membrane of the incised decagonal peristome with ten large plates carrying spines, pedicellariæ, and tentacles. Spines hollow, thin, very verticillate and striated longitudinally, long and slender, some small and club-shaped.

*Recent.* Mediterranean, Canaries, Australia, New Caledonia, W. coast of Central America.

Former genus *PSEUDODIADEMA*, *Desor*, 1858, *Synopsis*, p. 63, pars. *Duncan*, 1885, *Quart. Journ. Geol. Soc.* vol. xli. p. 430. *Cotteau*, 1864, *Rev. et Mag. de Zool.* 2 sér. vol. xvi. p. 288. (Now *DIADEMA*.)

Syn. *Tetragramma*, *Agass.*; *Hebertia*, *Mich.*

Test small and moderate in size, thin, tumid at the circular ambitus, swollen to subconical dorsally, depressed, flat or re-entering actinally.

Apical system small, ornamented; the periproct circular or somewhat elongate, and even unsymmetrical; basal plates narrow; radial plates small, equal or unequal, and some may enter the periproctal ring; the pore close to the adoral edge; madreporite distinct and in the right anterior basal plate.

Ambulacra much narrower than the interradia; plates as single low primaries near the apex and soon becoming compound, the central component with the tubercle, a primary, and the adoral and aboral constituents also primaries, their sutures curved, convexity towards the tubercle; sometimes a demi-plate near the peristome. Pairs of pores in simple straight series near the apex and in the same towards the ambitus, or in slight arcs

of triplets slightly crowded near the peristome; primary tubercles in two rows, perforate and crenulate, fairly developed.

Interradia wide, with two or more vertical rows of primary tubercles, larger than those of the ambulacra, and otherwise similar; secondary tubercles may exist with or without a distinct and often crowded granulation. Some diminution in the size of the tubercles and of the number of vertical rows may occur dorsally.

Peristome moderate, nearly flush or incurved, decagonal, with large branchial incisions, having a raised edge. Jaws well developed, with a large foramen, without epiphyses; teeth grooved; perignathic girdle continuous. Spines variable in size, short, or longer than the diameter of the test, striated longitudinally, finely tapering, cylindrical pointed (solid, and this condition is due to fossilization).

*Fossil.* Lias, Oolites, Cretaceous: England, Europe, N. Africa, Egypt, Asia, N. America; probably Eocene, Europe (*Hebertia*).

The alliance of *Microdiadema*, *Diademopsis*, *Hemipedina*, and *Echinodiadema* (Cott.) with the old genus *Pseudodiadema* is evident. The imperforation and non-crenulation, or the reverse conditions, of primary tubercles are insufficient to define and limit genera. Now all these "genera" are placed as subgenera with *Pseudodiadema*, which is synonymous with *Diadema*.

Subgenus MICRODIADEMA, *Cotteau*, 1863 (genus), *Rev. et Mag. de Zool.* sér. 2, vol. xv. p. 225.

Test small, swollen and hemispherical abactinally, re-entering actinally.

Apical system solid, narrow, projecting, granular.

Ambulacra with the pairs of pores in simple vertical series; arrangement of plates "diadematoïd." Interporiferous areas with small, almost uniform, perforate and crenulate, scrobiculate primary tubercles in several vertical rows.

Interradia with primary tubercles resembling those of the ambulacra in several vertical rows.

Peristome large, subcircular or decagonal, with well-developed branchial incisions.

*Fossil.* Lias: Europe.

Subgenus DIADEMOPSIS, *Desor*, 1858 (genus), *Synopsis*, p. 79.  
*Cotteau*, 1864, *Rev. et Mag. de Zool.* sér. 2, vol. xvi. p. 212.

Test moderate and small, depressed, but subconical above the tumid ambital outline. Coronal plates low and numerous.

Apical system large; madreporite and the basals large; radial plates between the basals, but excluded from the periproct.

Ambulacra narrow, with very small perforate and plain primary tubercles in two rows; pairs of pores in simple vertical series, rarely, but sometimes, crowded at the peristome; plates low, simple primaries near the apical system, and compound elsewhere; the adoral constituent a small primary with its aboral suture convex; the median plate a large primary, and the aboral plate a low primary with the adoral suture convex (diadematoïd).

Interradia with four vertical rows of small perforate, plain, primary tubercles, without scrobicules, rather larger than those of the ambulacra; the outer vertical rows reach up furthest abactinally, and hence a granular median area.

Peristome large, branchial grooves moderate. Spines longer than the diameter of the test, very delicate and slender, sharp, striated longitudinally, solid.

*Fossil.* Infra-Lias and Lias: England and Europe.

Étallon remarked long since upon the slight value of the genus *Hemipedina* and noticed that crenulation of the tubercles is sometimes visible on some portions of a test. Hence the plain condition is in this, as in other groups of forms, not of generic value. It is not possible to separate *Hemipedina* from *Diadema* generically, but the species formerly associated with it form a somewhat natural series, and may enter a subgenus.

Subgenus HEMIPEDINA, *Wright*, 1855 (genus), *Pal. Soc. Monogr.*, *Ech. Foss. Oolit. Form.* p. 143. *A. Agassiz*, 1872-74, *Revision*, p. 291. *Duncan*, 1885, *Quart. Journ. Geol. Soc.* vol. xli. p. 42. *Döderlein*, 1886, *Wieg. Archiv*, Heft i. p. 96.

Test moderate in size or small, circular or slightly pentagonal at the tumid ambitus, flat actinally, depressed, tumid, or subconical dorsally. Coronal plates numerous.

Apical disk large, with large united basal plates.

Ambulacra narrow, straight; pairs of pores in straight series or in arcs of three; simple primary plates near the apex, compound plates elsewhere as in *Diadema*; tubercles in two vertical rows perforate and not crenulate; secondary tubercles exist and granules.

Interradia large, and with from two to six vertical rows of small primary tubercles, but larger than those of the ambulacra, only the outer rows reach the apex, perforate, and some may be crenulated. Median area often bare or granular near the apex; secondary tubercles form rows near the ambulacra.

Peristome moderate, decagonal, and with rather deep branchial incisions; ten buccal plates upon the peristomial membrane. Spines long and slender, needle-shaped, longitudinally striated.

*Fossil.* Lias and Oolites: England, Europe. Cretaceous: Europe.

*Recent.* Caribbean Sea, 138–270 fms.; Sigambai, Japan.

Subgenus ECHINODIADEMA, *Cotteau*, 1869 (genus), *Rev. et Mag. de Zool. sér. 2*, vol. xxi. p. 238, pl. xli. (*non Verrill*).

Test small, subconical. Ambulacra with undulating or straight poriferous zones; three pairs of pores directly superimposed to a compound plate, forming arcs actinally; arrangement "diadematoïd." Ambulacral and interradial tubercles nearly equal, plain, most numerous and largest actinally; each interradial tubercle corresponding to a swelling of a plate. Granulation distinct and distant, considerable.

Peristome large, subcircular, with branchial incisions.

*Fossil.* Oolite: Europe.

Genus PLACODIADEMA, *Duncan*.

Syn. *Plesiadiadema*, *Dunc.* (*non Pomel*), 1885, *Quart. Journ. Geol. Soc.* vol. xli. p. 433, fig. viii. *De Loriol*, 1887, *Faune Crét. du Portugal*, *Éch.* fasc. i. p. 31.

Test of moderate size, depressed, circular in marginal outline, tumid dorsally and flatter actinally.

Apical system small, compact, the five basal plates and five radial plates all perforated.

Ambulacra moderately broad, the poriferous zones with numerous pairs of pores in simple vertical series or somewhat arched; plates high, compound, made up of from four to six component primary plates, the sutures curved, with their convexities towards the centres of the plates, the second component from the adoral suture of the compound plate being the largest primary component; a pair of pores to a component plate. Interporiferous areas with two vertical rows of small primary tubercles, perforate and crenulate.

Interradia wider than the ambulacra, with two or more rows of primary tubercles, resembling those of the ambulacra. Peristome decagonal, moderate, and with branchial incisions. Spines striated, moderately long, hollow (see specimen in *Brit. Mus.*).

*Fossil.* Oolite: Europe. Cretaceous: England and Europe.



Genus HETERODIADEMA, *Cotteau*, 1862, *Rev. et Mag. de Zool.* sér. 2, vol. xiv. p. 200. *De Loriol*, 1887, *Faune Crét. du Portug.*, *Éch.* fasc. i. p. 44. (See *Pseudodiadema* (*Heterodiadema*) *Pseudo-Bourgeti*, *Cott. Pal. Franç.*, *Terr. Crét.* vol. vii. pl. 1097.) (*Amended.*)

Syn. *Loriolia*, *Neumayr*, 1881, *Zeits. d. deutsch. geol. Gesellsch.* Bd. xxxiii. p. 571; *Colpotiara*, *Pomel*.

Test moderate, circular in tumid ambital outline, subconical, swollen but depressed abactinally, convex and rarely flat actinally.

Apical system long, and when absent leaving a large scar which intrudes a considerable distance into the depressed posterior interradius. When present, the madreporite is large and passes from the right anterior basal plate to the centre of the system and pushes backwards the periproct, which is bounded by the postero-lateral basal plates and the postero-lateral radial plates and one or two interradial plates. Moreover, the antero-lateral radial plates separate the pairs of basal plates, and either touch the madreporite, or come into the periproctal ring; fifth basal plate absent.

Ambulacra with straight, narrow poriferous zones; the pairs of pores in simple series, except actinally, where there is some doubling; plates compound (diadematoid). Tubercles of both areas in vertical rows, moderate in size, very equal, perforate and crenulated. Peristome flush, decagonal, with branchial incisions.

*Fossil.* Cretaceous: Europe, N. Africa, Asia (Syria).

Genus CODIOPSIS, *Agassiz*, 1840, *Cat. Syst. Ectyp. Ech. Foss.* p. 19. *Desor*, 1858, *Synopsis*, p. 112. *De Loriol*, 1887, *Faune Crét. du Portug.*, *Éch.* fasc. i. p. 57, pl. ix. (*Amended.*)

Test moderate, swollen, high, often nearly globular, circular or pentagonal in marginal outline; coronal plates numerous, high.

Apical system small, solid.

Ambulacra straight, narrow; pairs of pores uniserial, in very slight arcs; the plates low primaries, but near the peristome they are compound, the middle component a large primary, and the aboral and adoral components demi-plates. Primary tubercles of both areas small, smooth, nearly equal in size, and only occurring actinally and for a short distance towards the ambitus, a granulation being elsewhere. Peristome pentagonal, small, with slight branchial incisions.

*Desor* states that the primary tubercles are perforate, but they are not so in available specimens.

*Fossil.* Cretaceous: Europe, N. Africa, Egypt.

Genus PLEURODIADEMA, *De Loriol*, 1870, *Éch. Helv. Jura*, p. 196 ;  
and 1885, *Mém. Soc. Pal. Suisse, Genève*, p. 18.

Test of moderate size, more or less swollen above and flat below.  
Apical system well developed, flush, compact.

Ambulacra narrow at the apex, with some projecting, imperforate, smooth or slightly crenulate tubercles on the actinal surface only, the rest granular. Poriferous zones straight; pairs of pores in simple series, directly superimposed and separated by small horizontal costæ, which are raised, distinct and stout, especially actinally, and are prolonged to the interradial tubercles.

Interradia actinally and at the ambitus with two rows of wide-apart, projecting tubercles with large mamelons, without scrobicules, and imperforate, slightly crenulate. Very small tubercles abactinally, secondary tubercles absent.

Peristome decagonal, with everted edges; branchial cuts small.  
*Fossil*. Jurassic: Europe.

Genus MAGNOSIA, *Michelin*, 1853, *Rev. et Mag. de Zool. sér. 2*,  
vol. v. p. 34. *Desor*, 1858, *Synopsis*, p. 115. *De Loriol*,  
1887, *Faune Crét. du Portug.*, *Éch. fasc. i.* p. 59.

Test small or moderate, circular at the tumid ambital outline, subhemispherical dorsally, or depressed, concave actinally. Coronal plates numerous, low.

Apical system small; periproct small.

Ambulacra narrow except actinally, where they are broad; pairs of pores in simple straight series, barely in slight arcs of triplets, but near the peristome they become close and polyserial. Plates compound. Interporiferous areas with from two to six or more oblique rows of very small plain primary tubercles.

Interradia with a median depression, abactinally, which is smooth; from four to nine horizontal or oblique rows of very small tubercles resembling those of the ambulacra, diminishing in number abactinally.

Peristome very large, pentagonal, well incised, the ambulacral lips the largest.

*Fossil*. Oolite: England and Europe. Cretaceous: Europe and N. Africa.

The Liassic species described by M. Cotteau cannot well enter, and, as he suggests, should be removed.

Genus *COTTALDIA*, *Desor*, 1858, *Synopsis*, p. 113.

Test thin, small or moderate in size, tumid, subhemispherical or subconical, slightly depressed, circular or subpolygonal in ambital outline, flat and slightly tumid actinally.

Apical system small, one or both of the posterior radial plates may enter the periproctal ring. Coronal interradial plates very numerous, low and broad.

Ambulacra narrow; the poriferous zones narrow, slightly sunken, straight, the pairs of pores in simple vertical succession, slightly in arcs actinally; plates compound, there being three low primaries in each, with almost straight sutures. Interporiferous areas slightly tumid, crowded with very small perforate non-crenulate tubercles in horizontal rows, with or without order, and large granules.

Interradia wide, the low plates with very numerous tubercles resembling those of the ambulacra, placed in a horizontal row on each plate, and with granules nearer the transverse sutures.

Peristome sunken, small; the branchial incisions small; the interradial lips the largest.

*Fossil.* Cretaceous: England, Europe, and N. Africa.

*Recent.* — ?

A. Agassiz admits his *Cottaldia Forbesiana* ('Challenger' Report, p. 182) into the genus with much reservation; and I agree with him that the generic position is doubtful. *Cottaldia Carteri*, Dunc., from the Cretaceous of Ras Fartak, Arabia, must enter the genus *Orthopsis*.

## II. Subfamily *Diplopodiniæ* (p. 59).

Genus *DIPLOPODIA*, *McCoy*, 1848, *Ann. & Mag. Nat. Hist.* ser. 2, vol. ii. p. 412. *Desor*, 1858, *Synopsis*, p. 75. *Duncan*, 1885, *Quart. Journ. Geol. Soc.* vol. xli. p. 443. *De Loriol*, 1887, *Faune Crét. du Portug.*, *Éch.* fasc. i. p. 33.

Test moderate, depressed, circular in tumid ambital outline.

Ambulacra narrow, with two vertical rows of primary tubercles, perforate and crenulate, smaller or nearly equal in size to the interradial tubercles; pairs of pores in double vertical series near the apex and peristome, and uniserial at the ambitus; there is much crowding out of the poriferous plates in the biserial parts; at the ambitus there are four primary components to a compound plate, or the lowest component may be a demi-plate, the second

primary from the adoral suture of the compound plate is the largest component.

Interradia with two or more vertical rows of primary tubercles, which are large and otherwise similar to those of the ambulacra.

Peristome with well-marked branchial incisions.

*Fossil.* Oolite: Europe. Cretaceous: England, Europe, Asia, N. Africa.

*Diplopodia* is very interesting in the construction of the ambulacral plates, which, when compound, are "diadematoïd;" on the other hand, *Pedinopsis*, according to De Loriol, has the middle plates of its compounds formed upon the "*Echinus*" type first described by J. Müller.

Genus PEDINOPSIS, Cotteau, 1863, *Éch. Foss. de Pyrén., Extr. de Congr. Sci. de France*, 28 Sess. Bordeaux, p. 16; 1879, *Éch. Foss. de l'Algér.* fasc. 5, p. 207 (P. Desori). De Loriol, 1887, *Faune Crét. du Port., Éch.* fasc. i. p. 53, pl. x. figs. 7, a, b.

Test moderate, thin, tumid, subconical, flat actinally.

Ambulacra moderately wide; pairs of pores biserial throughout, or polyserial at the peristome, or uniserial at the ambitus; interporiferous area with two or more vertical rows of small perforate and crenulate primary tubercles; the compound plates high, numerous, and the middle plate of each arranged with the others upon the "*Echinus*" type.

Interradial areas with numerous plates not much higher than the compound ambulacral plates, with several or numerous rows of small distant primary tubercles, resembling those of the ambulacra and diminishing in number abactinally.

Peristome with feeble branchial incisions.

*Fossil.* Cretaceous: England, Europe, N. Africa.

Genus ACANTHECHINUS, Duncan & Sladen, 1882, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, pt. ii. p. 34, pl. viii.

Test turban-shaped, flat actinally.

Ambulacra convex from side to side, one half of the breadth of the interradia, with two vertical rows of primary tubercles; pores in numerous pairs, diplopodous apically, in single series actinally, very numerous, close, from five to eight pairs to a compound plate; zone narrowest actinally, slanting from the interporiferous

areas. Every compound plate has not a tubercle, for smaller wedge-shaped compound plates intervene between those with tubercles.

Interradia with sunken median areas ; plates distinctly sutured and high. Primary tubercles of both areas well developed, some on raised areolæ, all with a broad-based conical boss, largely crenulated, with ridges passing down their tall flanks, and a small imperforate mamelon. Secondary tubercles and granules sharply pointed and spiny.

The apical system and peristome of the species of this interesting group are lost.

*Fossil.* Eocene : Asia, W. Sind.

The place of this genus must be provisionally with the *Diamematidæ*.

Genus *PHYMECHINUS*, *Desor*, 1858, *Synopsis*, p. 133, pl. xvii. *bis*.

Test rather large, tumid in marginal outline, subhemispherical, and depressed abactinally, broad, flat, and slightly tumid actinally. Coronal plates numerous.

Apical system small ; madreporite large ; basals unequal, some radial plates entering the periproctal ring.

Ambulacra straight, rather broad, especially actinally ; pairs of pores diplopodous, close vertically, crowded at the peristome ; plates compound, with at least five pairs of pores. Interporiferous areas with two vertical rows of large, projecting, plain, imperforate primary tubercles, with many surrounding granules, extending from the peristome to the apex.

Interradia broad, with two very prominent vertical rows of primary tubercles, resembling in structure those of the ambulacra, but larger, with four rows of small secondary tubercles, extending nearly to the peristome and diminishing above the ambitus.

Peristome very large, decagonal, with very decided branchial incisions ; interradial lips small.

*Fossil.* Oolite : Europe.

Genus *ASTEROPSIS*, *Cotteau*, 1883, *Bull. Soc. Zool. de France*, sér. 2, vol. viii. p. 450.

Test of moderate size, circular in ambital outline, swollen

above, depressed and subpulvinate actinally. Apical system wanting, large.

Ambulacra with two vertical rows of small, imperforate, crenulate, primary tubercles; poriferous zones straight, the pairs biserial to below the ambitus, in barely oblique triple combinations, not increasing near the peristome.

Interradia with abactinal bare median areas, broad, with two vertical rows of small distant primary tubercles resembling the ambulacral, with large bosses and small mamelons, all diminishing abactinally, scrobiculate; small crenulated secondaries between the primaries and the poriferous zones; granules abundant around the tubercles.

Peristome sunken, subcircular. Spines slender, elongate, cylindrical, marked throughout with granular costæ, which are regularly placed; the ring is crenulated.

*Fossil.* Upper Cretaceous: Europe.

Genus *DIPLOTAGMA*, *Schlüter*, 1871, *Zeitsch. f. d. ges. Naturw.* (*Giebel*), n. F., Bd. iv. p. 339. *Zittel*, 1879, *Palæontol.* Bd. i. Lief. iii. p. 509.

Test thick, high, conical, spheroidal.

Apical system small, with a narrow ring.

Ambulacra broad; pairs of pores biserial, and with from five to eight pairs to each tubercle-bearing plate; plates compound. Tubercles similar in both areas, plain, numerous.

Peristome small, central; branchial incisions small.

*Fossil.* Cretaceous: Europe.

Genus *MICROPYGA*, *A. Agassiz*, 1879, *Proc. Amer. Acad.* vol. xiv. p. 200; *Report on 'Challenger' Echini*, 1881, p. 67. *Duncan*, 1885, *Journ. Linn. Soc. (Zool.)*, vol. xix. p. 110, pl. 5. fig. 11.

Test large, thin, flat actinally, with a rather sharp circular or subpentagonal ambitus, arched upwards towards the low flattened abactinal surface, broader than high.

Apical system central, with a small periproct, its membrane with small plates, with miliaries; anal opening minute. Basals uniform, largely perforate, angular towards the interradia. Madreporite in the usual basal. Radial plates all entering the narrow periproctal ring, concave at the distal edge where the pore is situate.

Ambulacra narrow, with two vertical rows of perforate, plain, primary tubercles; the poriferous zones with diplopodous pairs, which are numerous, close vertically, distant horizontally, and regular. Plates numerous, low, broad, composed above the ambitus, as elsewhere, of three small plates; the adoral and aboral are low broad demi-plates and the middle plate is a primary which carries the tubercle and occupies the median suture. Pairs of pores of a compound plate really in low broad triplets; only every alternate compound plate has the adoral pair of pores nearest to the ambulacral median line.

Interradia with many low broad plates, with many vertical rows of perforate primaries slightly larger than those of the ambulacra, ceasing at the ambitus, and largest there; and two rows extend vertically to the apex.

Peristome moderate, star-shaped, with broad projecting ambulacral ends, having a well-marked branchial incision and a tag on either side, the interradial margins being more pointed and narrower than those of the ambulacra. Peristomial membrane with imbricating plates.

Jaws and teeth "diadematoïd." Spines short, slender, and striated above the ambitus, slender and blunt club-shaped actinally.

*Recent.* Philippines, Fiji Islands; 100-600 fathoms.

Genus *PLISTOPHYMA*, Péron & Gauthier, 1881, *Éch. Foss. de l'Algér.* fasc. 8, p. 176, pl. xx.

Test moderate, circular at the tumid ambitus, very depressed, nearly three times as broad as high.

Apical system large and subpentagonal.

Ambulacra narrow, straight, with two vertical rows of imperforate plain primary tubercles. Poriferous zones with the pairs of pores biserial, actinally and dorsally, and in simple series at the ambitus.

Interradia broad at the ambitus, the median area distinct and bare abactinally; four or five vertical rows of primary tubercles in each (or more); tubercles resembling those of the ambulacra, those next to the median suture the largest and passing up to the apex, rows oblique; plates numerous, low, broad, and oblique, especially at the ambitus.

Peristome large, pentagonal; branchial incisions small.

*Fossil.* Cretaceous: Europe and N. Africa.

Cotteau, 1882, Bull. Soc. Géol. de France, sér. 3, vol. x. p. 346, considers the genus to be close to *Magnosia*, and that there is a species at Martigues; but the structure of the apical system and of the poriferous zones forms a decided distinction.

### III. Subfamily *Pedininae* (p. 59).

GENUS PEDINA, *Agassiz*, 1840, *Éch. Foss. de la Suisse*, p. 33.  
*Wright*, 1855, *Pal. Soc., Ech. Ool. Form.* p. 171. *Duncan*,  
 1885, *Quart. Journ. Geol. Soc.* vol. xli. p. 433.

Test large and moderate, thin, circular or slightly pentangular in tumid ambital outline, depressed.

Apical system small, with nearly equal basal plates and small excluded radial plates; periproct moderate.

Ambulacra narrow; poriferous zones wide; pairs of pores in oblique triserial ranks, really in exceedingly arched triplets. Plates low, crowded, and consisting of three components, each with a pair of pores, the pair nearest the median ambulacral line being in the adoral plate, which is either a long low primary plate or a demi-plate, with its aboral suture convex towards the middle component; the middle plate of the three is the largest, is a primary, and its pair of pores is nearest the interrado-ambulacral suture; the aboral plate is either a low primary or a demi-plate, and its adoral suture is convex towards the middle plate, its pair of pores is further from the suture between the interradium and ambulacrum than the pair of the middle plate. Tubercles in two vertical rows; and they are small perforate primaries.

Interradia broad, and with two vertical rows of small primary tubercles resembling those of the ambulacra, extending from peristome to apex, and two or four rows of secondary tubercles, which cease at or above the ambitus.

Peristome small and with branchial incisions.

*Fossil*. Oolite: England; Europe.

Subgenus PSEUDOPEDINA (genus), *Cotteau*, 1858, *Rev. et Mag. de Zool.* sér. 2, vol. x. p. 221; 1884, *Pal. Franç., Jura*, livr. 66, p. 661, pl. 439.

Test subcircular in marginal outline, depressed or subhemispherical.



Apical system large, granular, flush; basals large, high, extending into the interradia somewhat; radials small; periproct small, pentagonal.

Ambulacra narrow, straight, having distant, large, perforate, non-crenulate primary tubercles on the flat actinal surface and near the ambitus only. Pairs of pores in oblique triplets, the aboral pair being nearest the interradium, and the adoral nearest the median ambulacral line. Plates low, compound, the three components being "diadematoïd" primaries.

Interradia with large perforate non-crenulate tubercles diminishing abactinally; plates high and granular.

Peristome large, decagonal; branchial incisions large.

*Fossil.* Oolite: Europe.

The size of the primary tubercles characterizes this subgenus of *Pedina*.

Genus ECHINOPEDINA, Cotteau, 1866, *Rev. et Mag. de Zool.* sér. 2, vol. xviii. p. 362.

Syn. *Echinopsis* (pars).

Test moderate, spheroidal or subspheroidal, flattened above and actinally.

Apical system with a narrow ring and a large madreporite; the posterior radials entering the periproctal ring.

Ambulacra broad and straight, with broad poriferous zones, the pairs in decided arcs of triplets, more or less biserial or triserial; a vertical row of perforated, non-crenulate small primary tubercles close to each poriferous zone; small secondaries or large granules nearer the median line.

Interradia with two vertical rows of small primary tubercles resembling those of the interradia, the broad median space being occupied by rows of granules or small secondaries.

Peristome small, and with branchial incisions fairly developed.

*Fossil.* Eocene: England and Europe; America, Cuba.

The arched nature of the triplets of the ambulacra distinguishes *Echinopedina* from *Echinopsis*. *Echinopedina Gacheti* of the French Eocene is the type.

Cotteau has described *Echinopedina cubensis* from the Eocene of Cuba (*Ann. de la Soc. Géol. de Belg.* t. ix. Mémoires, 1881, p. 9, pl. i. figs. 1-6); and it only departs from the generic character by having a second vertical row of small primary and some secondary tubercles. The figure 3 of Cotteau's plate i. shows

ambulacral plates near the ambitus, and fig. 4 above the ambitus; the difference is remarkable. The adoral pair of pores (fig. 4) is nearer the ambulacral median line than the others, as in *Echinothrix*.

Genus STOMECHINUS, *Desor*, 1858, *Synopsis*, p. 124. *Duncan*, 1885, *Quart. Journ. Geol. Soc.* vol. xli. p. 435. *De Loriol*, 1887, *Faune Crét. du Port.*, *Éch.* fasc. i. p. 65, pl. x.

Test moderate and large, circular in tumid ambital outline, subconical or subhemispherical dorsally, more or less depressed. Coronal plates numerous.

Apical system with large angular basals forming the peri-proctal ring, and projecting into the interradia; radial plates small.

Ambulacra moderately wide; at a short distance from the apical system the pairs of pores are in close, oblique, triple series; three pairs to a compound plate, the adoral pair nearest the interporiferous area. A compound plate consists of an adoral and aboral low primary component, the sutures being convex towards the tubercle, and a large median primary carrying the greater part of the tubercle and forming the median sutural angle (diadematoïd). Interporiferous areas with non-crenulate imperforate primary tubercles arranged in two vertical rows, with or without additional rows in the median part.

Interradia with a primary tubercle on each coronal plate, similar to, or larger than, the ambulacral tubercles, imperforate and non-crenulate, thus forming two main vertical rows; a varying number of small secondary tubercles and granules on either side of the primary tubercles; median area may be bare near the apex.

Peristome large, pentagonal; branchial grooves large, with raised rims; ambulacral margins much larger than the interradi- al. Spines small, short, blunt, striated longitudinally.

*Fossil.* Oolite: England and Europe; America, South. Cretaceous: Europe.

M. de Loriol's species *S. camarensis* (*op. cit.* p. 65) is abnormal; for nothing can be clearer than the "diadematoïd" nature of the ambulacral plates of the British types. The narrowness of the ambulacra of the peristome, the small branchial incisions, and the demi-plates of the ambulacra characterize M. de Loriol's species, but do not bring it within our idea of *Stomechinus*.

Genus MICROPEDINA, *Cotteau*, 1866, *Pal. Franç., Terr. Crét.* vol. vii. p. 822, pl. 1197. fig. 8. *Stoliczka*, 1873, *Cret. Fauna of S. India*, vol. iv. 3 ser. viii. 3. *Echin.* p. 41, pl. vi. *De Loriol*, 1887, *Faune Crét. du Port., Éch.* fasc. i. p. 61, pl. x.

Test of moderate size, circular in tumid ambital outline, spheroidal, depressed actinally, or generally depressed.

Apical system small.

Ambulacra straight, slightly prominent; pairs of pores flush, in a narrow zone, either in straight or oblique series of triplets, the adoral pair being remotest from the interradius, and the aboral close to it. Plates low, composed of a low, broad, median primary component, and of adoral and aboral demi-plates, or the adoral may be a primary, the sutures convex towards the tubercles. Interporiferous area with several vertical rows of very small perforate, smooth, primary tubercles, most not reaching the apex.

Interradia with numerous low, broad, coronal plates, with very numerous vertical rows of primaries resembling those of the ambulacra, some of the plates with oblique rows. Rarely more than two vertical rows reach the apex.

Peristome small, circular; branchial incisions small.

*Fossil.* Cretaceous: Europe, N. Africa, S. India, Asia.

The next genus is represented by a very fine species in the Inferior Oolite of France, *Heterocidaris Trigeri*, *Cotteau*, and by a small fragment of a probably second species, *H. wickense*, *Wright*, from the Inferior Oolite of Yorkshire. But although *Cotteau* had the advantage of examining a fine specimen which was admirably drawn by *Humbert*, *Wright*, under unfavourable circumstances, placed the species in their proper family, and noted the affinities with *Astropyga* of the recent fauna. Following *Wright*, I am able to confirm his judgment in some points, after an examination of the structures of the ambulacra and peristome. *Cotteau* placed the genus amongst the *Cidaridæ*, and distinguished it from any of the *Diadematidæ*. This is to be regretted because really so much of our knowledge about the form is derived from his excellent work and *Humbert's* masterly drawing. *Wright* missed the points which I would press upon the distinguished French Echinodermatist, and considered that the narrowness of the ambulacra and width of the

interradia and their numerous tubercles allied the forms sufficiently with Diadematidæ and removed them from Cidaridæ.

I would point out that in Humbert's figure (Cotteau, *Éch. de la Sarthe*, Suppl. p. 338, pl. lvi. figs. 1-4) the outline of the margin of the peristome is decagonal, the ambulacral borders being very narrow and it is clear that there is a decided branchial cut on either side of the peristomial end of the best preserved ambulacrum. Moreover, there are indications, in the drawing of the peristome, that the perignathic girdle is not after the simple Cidaroid type. The statement of M. Cotteau that the pairs of pores form arcs near the peristome is strictly true, and the figure given by Humbert of the component plates of three compound poriferous plates and parts of an upper and lower one on fig. 4 are conclusive in respect of Cotteau's exactitude. If the upper pair of pores of the fig. 4, pl. lvi. (*Cott. op. cit.*), be removed and the lowest also (they belong to defective compound plates), it will be evident that three sets of triplets remain, and that each set is in a compound plate made up of three smaller plates, and that the middle one of each carries the tubercle. The thin lines indicate the sutures between the component plates of each compound plate; and it will be observed that the middle plate of each is the largest, occupies much of the plate at the tubercle end, which is near the median suture of the ambulacrum, and that its pair of pores is nearer the ambulacro-interradial suture than the other pairs of pores. Then it can be noticed that the adoral suture of the upper pore-bearing plate, in every compound plate, is slightly curved convexity adorally, and that it reaches the median ambulacral sutural line just above the base of the tubercle. The component plate is thus a low primary, and its pair of pores is placed remote from the ambulacro-interradial suture. On the other hand, the aboral suture of the lowest of the pore-bearing plates of each series has its convexity directed aborally, and it may be noticed that the end of the suture is either at the median line or falls short. In this last instance the plate is a demi-plate; but in either case the pair of pores is situated normally, that is, remote from the ambulacro-interradial suture. Now this arrangement of the plates composing a component ambulacral tubercle-bearing plate is essentially "diadematoid," and is most distinct from that of any Cidaroid. (Duncan, *Anat. Amb. Recent Diadematidæ*, *Journ. Linn. Soc. (Zool.)*, vol. xix. p. 96, 1885.)

The arrangement is represented in the recent forms of *Echinothrix*, to which genus the alliance is greater than to *Astropyga*. But other distinctions of structure between the genera are evident.

The fossil form has not the ambulacra with the width and convexity of those of *Echinothrix*, and the median interradial area near the apical system is tuberculate in *Heterocidaris*.

Genus HETEROCIDARIS, Cotteau, 1860, *Bull. Soc. Géol. de France*, sér. 2, vol. xvii. p. 378; *Éch. Foss. de la Sarthe, Suppl.* p. 338, pl. lvi. *Wright*, 1860, *Pal. Soc., Ech. Ool. Form.* p. 456. (*Amended.*)

Test large, circular in outline at the tumid ambitus, broader than high, flat actinally, subconvex abactinally.

Apical system absent in the specimens.

Ambulacra very narrow, straight, not projecting, with two vertical rows of very small perforate and crenulate tubercles. Poriferous zones slightly depressed, narrow; pairs of pores in almost straight series at and above the ambitus, although in triple compound plates; near the peristome the pairs of pores are in arcs and oblique; the tubercle of a compound plate is on the middle component plate, and the sutures of the adoral and aboral component plates and the middle plate are curved more or less, their convexities directed towards the middle plate. Usually the components are low, broad primaries; but a demi-plate may occur near the actinosome.

Interradia very broad and tumid; the plates low and broad, carrying several rows of large, perforate, crenulate and scrobiculate primary tubercles separated by a rich granulation. The vertical rows diminish above the ambitus; but at least four reach close to the apical system, especially the pair close to the ambulacra, so that the median vacant space is very small and insignificant.

Peristome small, decagonal; ambulacral ends small, with branchial incisions on their flanks. Spines long, cylindrical, striated longitudinally.

*Fossil.* Inferior Oolite: England, Europe.

M. Cotteau states that the auricular processes must have been strong.

Genus ECHINOTHRIX, *Peters*, 1853, *Abh. k. Akad. Wiss. Berlin*, (1854), p. 114. *A. Agassiz*, 1872-4, *Revision*, p. 413. *Duncan*, 1885, *Journ. Linn. Soc. (Zool.)*, vol. xix. pp. 101 and 202. *Lovén*, 1887, *Ech. desc. by Linnæus*, p. 137. (*Amended.*)

Syn. *Garelia*, Gray; *Savignia*, Desor.

Test large, thin, tumid, moderately high, depressed, broad.

Apical system large, more or less sunken; basals large and projecting into the interradial spaces; radials small and entering the ring; the periproct large, with a close pavement of plates. Coronal plates numerous.

Ambulacra tumid, narrow, with several vertical rows of very small tubercles, which are crenulate and perforated, diminishing in number actinally; plates numerous, low, broad, composed of three primaries, with the sutures convex towards the tubercle; near the peristome the adoral component is small and excluded from the interradial suture. Pairs of pores large, in close arcs, the adoral pair nearest the ambulacral median line, forming, with others, a vertical series.

Interradia with a bare median space, sunken, elsewhere several vertical rows of large primary tubercles, crenulated and perforated, scrobiculate, diminishing in number abactinally.

Peristome large, with deep branchial incisions and tags; membrane with small plates. Perignathic girdle with very broad, low ridges; processes expanded above, opening large. Jaws with the foramen of the pyramid an open arch, the teeth grooved. Spines slender, long, striated, verticillate, more or less solid.

*Recent.* E. coast of Africa, Pacific Islands, Japan, Philippines, E. Indian Islands, Red Sea.

Genus ASTROPYGA, *Gray*, 1825, *Ann. Phil.* vol. xxvi. p. 246. *Peters*, 1853, *Abh. k. Akad. Wiss. Berlin* (1854), p. 110. *A. Agassiz*, 1872-4, *Revision*, p. 417; 1881, *Report on 'Chal-lenger' Echini*, p. 72, pl. x. a. fig. 9. *Duncan*, 1885, *Journ. Linn. Soc. (Zool.)*, vol. xix. p. 106, pl. v. (*Amended.*)

Test large, tumid at the ambitus, depressed, thin, more or less flexible; ambulacra bulging.

Apical system large; basals large, triangular, elongate; radials much smaller, narrow, and entering the periproctal ring. Membrane with circular rows of plates.

Ambulacra narrow, convex, with two vertical rows of large,

crenulate and perforate primary tubercles ; poriferous zones broad ; plates compound, large, high, composed at the ambitus and actinally of two sets of triplets, each consisting of low, broad primaries, sometimes with a demi-plate, with their sutures curved, convexity towards the tubercles ; pairs of pores in oblique sets of three pairs, really in close triplets, the adoral pair of a compound plate being nearest the ambulacral median line and the aboral the most remote.

Interradia with a broad median area abactinally, elsewhere with several rows of crenulate and perforate primaries, slightly larger than those of the ambulacra, each with a large flat scrobicule. Coronal plates rather numerous, low and broad, overlapping more or less, pitted inside and some split longitudinally or not.

Peristome variable in size ; branchial cuts large ; membrane with plates, the largest carrying spines. Jaws small ; teeth grooved. Larger spines about one half of the diameter of the test, striated, verticillate.

*Recent.* Panama, Gulf of California, Zanzibar, Philippines, East-Indian Islands.

Genus POLYCYPHUS, *Agassiz*, 1846, *Cat. Rais. des Éch.*, *Ann. d. Sci. Nat.* sér. 3, vol. vi. p. 361. *Desor*, 1858, *Synopsis*, p. 117. *Cotteau*, 1863, *Rev. et Mag. de Zool.* sér. 2, vol. xv. p. 261.

Test small, subconical or hemispherical dorsally, tumid at the circular ambitus, rather flat actinally.

Apical system small ; basal plates large and united ; periproct oblique or not.

Ambulacra straight, rather wide, with rather broad poriferous zones, which may be sunken ; pairs of pores in close and very oblique triplets, triserial abactinally and polyserial actinally ; plates low, compound, "diadematoïd." Tubercles of the interporiferous areas small, plain, in four or more vertical rows, the outer the larger.

Interradia with numerous low broad plates, each with two horizontal rows of numerous plain tubercles, resembling those of the ambulacra ; but one row has small tubercles ; usually the tubercles increase in size actinally ; vertical rows five or more in number.

Peristome large, decagonal ; ambulacral lips large ; branchial incisions well developed.

*Fossil.* Oolite : England and Europe.

Genus CODECHINUS, *Desor*, 1858, *Synopsis*, p. 111. *Cotteau, Pal. Franç., Terr. Crét.* vol. vii. pl. 1198. fig. 6.

Test small, tumid, spheroidal, flattish actually. Coronal plates high.

Ambulacra broad; poriferous zones broad; pairs of pores triserial, close, in nearly horizontal triplets: plates compound, low, some of three low primaries, "diadematoïd"; others with a large middle primary, a low aboral demi-plate, which is broad, and an adoral demi-plate which is excluded from the interradiial suture. The middle pair of pores is nearest the interradium. Tubercles very small, plain, distributed irregularly, most numerous and closest actinally, but few elsewhere.

Interradia with the median sutural area rather depressed; tubercles resembling those of the ambulacra, limited to parts of plates remote from the median line of the area, which is naked. A minute granulation separating the tubercles of both areas. Peristome small, central, diagonal.

*Fossil.* Cretaceous: Europe, N. Africa.

#### IV. Subfamily *Orthopsinæ* (p. 59).

Genus ORTHOPSIS, *Cotteau*, 1863, *Pal. Franç., Terr. Crét.* vol. vi. p. 550. *Stoliczka*, 1873, *Pal. Ind., Cret. Fauna S. India*, vol. iv. 3. viii. ser. 3, *Echin.* p. 45, pl. vii. *De Loriol*, 1887, *Faune Crét. du Port., Éch.* fasc. i. p. 46, pl. viii.

Test moderate in size or small, depressed, circular or slightly pentagonal in ambital outline, tumid dorsally, flat actinally.

Apical system with five perforated basals; madreporite well developed; radial plates, all or some entering the anal ring, which is variable in outline.

Ambulacra much narrower than the interradia, straight; pairs of pores numerous, in straight series; poriferous zone narrow; plates simple, low, primaries dorsally, but near the ambitus and actinally two primaries may combine, and the suture passes transversely through the interporiferous tubercle. Tubercles of the ambulacra small, perforate, and smooth; two vertical rows.

Interradia with several vertical rows of small primaries resembling those of the ambulacra, or slightly larger, some reaching up dorsally.

Peristome moderate, with well-developed branchial incisions;



perignathic girdle with ridges and processes which unite and form a small arch.

*Fossil.* Oolite : England, Europe. Cretaceous : Europe, N. Africa, Hindustan. Eocene : Egypt.

De Loriol has shown that *Hemipedina Semanni*, Wright, 1855, is an *Orthopsis*.

Genus *EODIADEMA*, gen. nov.

Test small, thin, circular in tumid marginal outline, subconical dorsally, tumid and re-entering actinally, broader than high.

Apical system moderate in size, ovoid or elliptical in the outline of the periproct ; five large basal plates, four in contact and the fifth or posterior separated from its fellows, on either side, by a radial plate.

Ambulacra narrow, straight, wider than the interradia at the peristomial margin, narrower elsewhere ; poriferous zones narrow ; the pairs of pores numerous, in simple vertical series, barely any crowding near the peristome ; plates all low, broad primaries ; interporiferous areas rather broad, crowded with blunt granules dorsally, some larger granules near the poriferous zones, and giving place at the ambitus to some very small crenulate and perforate tubercles which diminish actinally.

Interradia broad ; plates not numerous, broader than high ; two vertical rows of perforate, crenulate and scrobiculate primary tubercles in each area, a few large at the ambitus and becoming rapidly very small dorsally, or replaced by distinct, large, crowded granulation, diminishing also actinally. Scrobicules large at the ambitus, and usually coalescing. A large, blunt, very marked granulation occurs beyond the scrobicules on each plate, and also on all the plates up to the apex, except at an angular space contiguous with each basal plate, and extending downwards, variously, along each median line, where there are no granules, but a plain surface. Peristomial edge small and pointed.

Peristome sunken, decagonal, small, and with well-marked branchial incisions.

*Fossil.* Middle Lias : England.

This is a most interesting genus ; and the species *Eodiadema granulata* was discovered by E. Wilson, Esq., F.G.S., of the Bristol Museum. The alliance is very close to the *Orthopsidæ*, although

they have smooth tubercles as a rule. It is the single primary plates of the ambulacra without any compound ones, coupled with the small tubercles of the ambulacra and the few large primaries near the ambitus, all the rest of the test being granular, that separate the type from *Hypodiadema* and *Hemicidaris* and *Diadema*. It is very interesting to find such a simple form so low down in the Mesozoic series, and it may well have been the precursor of the genera just mentioned. The similarity of the genus to *Acrosalenia* is striking; but there is evidence that the sur-anal plates were not present.

If more was known about *Hypodiadema*, the alliance of the new genus with the oldest Mesozoic forms would be very definite; but the good drawings of Desor and other describers show that the interradia of the genera differ considerably.

MM. Péron and Gauthier have described *Cyphosoma Heinzi*, and notice its abnormal nature; and they consider that had it been placed in *Pseudodiadema* it would have been equally erratic. Probably the classificatory position is near *Orthopsis*, for the pairs of pores are in simple, low, primary plates. I have diagnosed a new genus for the form, and dedicate it to M. Péron.

#### GENUS PERONIA, gen. nov.

Syn. *Cyphosoma*, Cotteau, Péron et Gauthier, 1884, Éch. Foss. de l'Algérie (2nd edit. of fasc. 2), p. 96, pl. ix.

Test small, circular in tumid ambital outline, very depressed.

Apical system annular, pentagonal, symmetrical; periproct large, circular; basal plates equal, broad, low, perforated largely; radial plates small, all entering the ring and reaching the periproct, the margin of which is slightly raised.

Ambulacra narrow, with narrow poriferous zones, the pairs not numerous, and in simple vertical series throughout, each in a low primary plate. Interporiferous areas with small granules only.

Interradia broad, with only seven coronal plates on a side, with as many crenulate, imperforate and scrobiculate tubercles, largest at the ambitus, the rest of the plate granular; secondary tubercles absent.

Peristome large, decagonal, the branchial incisions with everted edges.

*Fossil.* Cretaceous (Neocomian): Algeria.

*Cyphosoma Heinzi* thus becomes *Peronia Heinzi*, Péron et Gauthier, sp.

Genus ECHINOPSIS, *Agassiz*, 1840, *Catal. Syst. Ectyp. Ech.* p. 18.  
*Desor*, 1854, *Synopsis*, p. 98 (pars). *De Loriol*, 1881, *Eoc. Ech. aus Ægypt. u. d. Lib. Wüste, Palæontographica*, n. F. x. i. (xxx.) p. 10.

Test thin, small or moderate in size, hemispherical, or subconical and tumid abactinally, rather flat actinally.

Apical system narrow, the basals unequal; the radials small and close to the periproct, but not forming its ring. Periproct large.

Ambulacra large, straight, flush with the test; pairs of pores in simple straight series; plates compound, triple, or quadruple, made up of low broad primaries; tubercles very small, close, perforate and non-crenulate, extending the whole length of the ambulacrum in two vertical rows placed near to the poriferous zones.

Interradia with two vertical rows of small primary tubercles, slightly larger than, but otherwise similar to, those of the ambulacra; minute granules surrounding the non-sunken scrobicules. Sutures of the plates distinctly seen.

Peristome small, slightly depressed; branchial incisions slight.  
*Fossil. Eocene: Europe, Egypt.*

*Echinopsis Edwardsi*, Forbes, of the London Clay, is an *Echinopedina*.

Genus GYMNOADIADEMA, *De Loriol*, 1884, *Recueil Zool. Suisse*, vol. i. No. 4, p. 606.

Test thin, tall, swollen, moderate.

Apical system flush; the madreporite triangular, slightly developed; radial plates small.

Ambulacra narrow; poriferous zones straight, with regularly superimposed pairs of pores in simple series; the plates very numerous, low, narrow primaries; interporiferous areas very narrow, have abactinally very small granules, which are barely visible to the naked eye, yet forming vertical series; they are replaced actinally by very small tubercles with perforate mamelons.

Interradia very broad, covered with granules like shagreen;

near the peristome there are some small tubercles, which are perforate and scrobiculate; they are more developed than those of the ambulacra.

Peristome (wanting) probably small.

*Fossil.* Oolitic: Europe.

The drawing of the solitary species given by De Loriol shows a globose test longer than broad, and very minutely granular; the increased size of the ornamentation actually is very characteristic.

*Genus incertæ sedis.*

GENUS PROGONECHINUS, *Duncan and Sladen, Pal. Ind.* ser. xiv.,  
*Foss. Ech. W. Sind*, p. 43, pl. x. figs. 1-4.

Test small, moderately high, subhemispherical, concave actinally; margin circular and tumid.

Apical system absent.

Ambulacra narrow, with straight poriferous zones having numerous pairs of pores directly superposed and close. The plates compound, the adoral component a low broad demi-plate, the middle a large primary plate carrying two small tubercles, and the aboral component a low broad primary; sutures grooved and distinct; tubercles plain, in two vertical series on each side of the median line, others near the ambitus; low granules often forming ridges.

Interradia broad; plates low; two persistent vertical rows of plain scrobiculate primaries larger than those of the ambulacra; at the ambitus two or more vertical rows occur besides, but are lost actinally and dorsally. Large granules with mamelons occur, and a row near each poriferous zone has costæ passing towards the pairs of pores and also to the scrobicules of the neighbouring primary tubercles. Grooves along the upper and lower sutures of the interradial plates near the median line.

Peristome circular; branchial incisions well developed, with thick everted margins.

*Fossil.* Eocene: Asia.

This is a very synthetic genus, and links the Diadematidæ and the Temnopleuridæ.

## V. Family CYPHOSOMATIDÆ.

Test moderate in size, circular or subpentagonal in tumid marginal outline, depressed, rarely subconical, highly ornamented; plates moderate in number or numerous.

Apical system very variable in size, shape, and structure, compact, or with some or all radials intervening between the basals, and the posterior basal intruding upon the posterior inter-radium; with the periproct posterior, and its plates either few or numerous and hexagonal; arms posterior; the madreporite in the right anterior basal.

Ambulacra with high compound plates, with from three to seven pairs of pores in an arc; near the apical system, and extending variously actinally, a biserial arrangement of the pairs, or not; pairs crowded or not at the peristome. The adoral and supra-adoral components are primaries, and the others demi-plates. Two vertical rows of primary tubercles. (Duncan, 1885, *Amb. Foss. Ech.*, *Quart. Journ. Geol. Soc.* p. 447.)

Interradia usually depressed dorsally, with bare median spaces; rows of tubercles variable in number, larger than those of the ambulacra.

Peristome moderate and large, with branchial incisions. Spines long and short, solid, some as needles; striated longitudinally.

This family subdivides with difficulty; and the two groups of it are not of subfamily value.

## Division I.

Genus *Cyphosoma*.

Subgenus *Leiosoma*.

Genus *Coptosoma*.

*Gauthieria*.

*Thylechinus*.

## Division II.

Genus *Micropsis*.

Subgenus *Gagaria*.

*Division I.*

Species with and without a diplopodous poriferous arrangement cannot be placed in the same genus; and therefore only the diplopodous species remain in the genus *Cyphosoma* as now constituted. Moreover, the genus now includes the species with the apical system encroaching upon the posterior inter-radium. Cotteau has found the details of the apical system; and

the typical arrangement is seen in *C. Delmarrei*, Pal. Franç., Terr. Crét. vol. vii. pl. 1140; see also *C. Foukanense*, Péron & Gauth. Foss. de l'Algér. fasc. 7, pl. vi. fig. 8.

Genus CYPHOSOMA, *Agassiz*, 1840, *Catal. Syst. Ectyp. Ech.* p. 19. *Desor*, 1858, *Synopsis*, p. 86. *Wright*, 1869, *Pal. Soc., Foss. Cret. Ech.* vol. i. p. 128. *A. Agassiz*, 1873, *Revision*, p. 487. *Duncan & Sladen*, 1882, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, p. 31. *Duncan*, 1885, *Quart. Journ. Geol. Soc.* vol. xli. p. 447. *J. Lambert*, 1888, *Bull. Soc. d. Sci. Nat. de l'Yonne*, 1 Semestre.

Syn. *Phymosoma*, *Haime*.

Test moderate in size, tumid at the circular or slightly polygonal ambitus, swollen but depressed dorsally and actinally, broader than high. Coronal plates few, their sutures distinct superficially.

Apical system large, with five basal plates; the madreporite in the usual plate, and all or some of the radial plates entering the periproctal ring, the posterior basal thrown more or less backwards and intruding upon the posterior interradium.

Ambulacra with well-developed poriferous zones, undulating; pairs of pores diplopodous abactinally, and in arcs of from four to six or more pairs, and more crowded still at the peristome; plates compound, high, formed of an adoral, a supra-adoral, and an aboral primary component, the other plates of the compound being demi-plates; the direction of the sutures of the primary plates of the compound is convex towards and on the boss of a large tubercle, the sutures usually being visible on its flanks. Two vertical rows of primary tubercles.

Interradia large, with two or more vertical rows of primary tubercles equal to or larger than those of the ambulacra and similar in their constitution, being imperforate and crenulate. Secondary tubercles exist, and small tubercles or granules in large numbers, the median areas often bare for some distance from the apical system.

Peristome small or moderate; branchial incisions well marked. Spines solid, long, subcylindrical, aciculate, or spathiform, straight or bent spoon-shaped, striated or smooth; milled head and acetabular cuts distinct.

*Fossil*. Oolite: Europe. Cretaceous: England, Europe, N. Africa, Asia. Eocene: Asia.

Subgenus *LEIOSOMA*, *Cotteau & Triger*, 1859 (genus), *Ech. du Dépt. de la Sarthe*, p. 271?, pl. xlv.; 1881, with *Péron et Gauthier*, *Ech. Foss. de l'Algér.* pt. 2 of fasc. 8, p. 141, figs. 7-11.

Syn. *Gomphechinus*, Pom.; *Micropeltis*, Pom.

The primary tubercles are plain, and neither crenulate nor perforate. Pairs of pores biserial throughout, or not so at the ambitus; several rows of interradial primary tubercles, or two only.

*Fossil.* Oolitic: Europe. Cretaceous: Europe and N. Africa.

Genus *COPTOSOMA*, *Desor*, 1858, *Synopsis*, p. 91. *Duncan & Sladen*, 1882-86, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, pp. 116-117, pl. xxii. *Duncan*, 1885, *Quart. Journ. Geol. Soc.* vol. xli. p. 447. *Lambert*, 1888, *Bull. Soc. d. Sci. Nat. de l'Yonne* (extrait), p. 7.

Syn. *Cyphosoma* (pars).

Test moderate, subconical, or depressed dorsally, tumid at the ambitus. Coronal plates few in number.

Apical system flush, intruding somewhat upon the posterior interradial spaces; one or more radial plates may enter the sub-circular or deformed periproctal ring; periproct somewhat thrown back.

Ambulacra with uniserial pairs of pores, and in arcs throughout; plates formed of more than three components, uniting after the *Cyphosomatoid* type.

Interradia with two vertical rows of primary tubercles, crenulated, and with several small secondaries upon each broad and comparatively low plate, larger than or of the same size as the primaries of the ambulacra; sutures may be visible, and the tubercles may be deficient dorsally.

Peristome moderate to large, with branchial incisions.

*Fossil.* Cretaceous: Europe, N. Africa, N. America. Eocene: Europe and Asia.

*Recent.* Japan.

The genus differs from *Cyphosoma*; for it is not diplopodous, and the poriferous plates have more than three components. It appears that very probably the recent *Phymosoma* = *Cyphosoma crenulare*, A. Ag., and also De Loriol's *C. Mortoni*, should come

in here. Unfortunately the name of the genus refers to cuts or sutural impressions upon the tubercles; and these are not characters of any importance. The fine Sindian forms of *Cyphosoma macrostoma*, Dunc. & Slad., and *C. undatum*, Dunc. & Slad., are now species of *Coptosoma*. *C. Joudi*, Péron et Gauth., should enter.

The genus *Microsoma*, Cotteau, 1886, Bull. Soc. Zool. de France, vol. xi. p. 715, is so doubtful on account of the bad condition of its specific type, that it is simply recorded.

GENUS GAUTHIERIA, Lambert, 1888, Bull. Soc. d. Sci. Nat. de l'Yonne, 1 Semestre (extrait), p. 7.

Syn. *Cyphosoma* (pars).

Test moderate, subcircular or subpentagonal, moderately tumid.

Apical system largely developed, pentagonal, with the posterior angle extending well into the corresponding interradium; the basal plates unequal; the madreporite in the largest and anterior lateral basal; the other lateral basals more or less hexagonal, and at the angles of the system the posterior basal forming a narrow rim to the posterior angle, and limiting the posteriorly excentric anus; radial plates large, all entering and separating the basals. Periproctal area large, and occupied by seven or more hexagonal plates, forming a closed area anterior to the circular anus.

Spines long, cylindrical, finely striated longitudinally.

*Fossil*. Cretaceous: England and Europe.

In one solitary instance this remarkable apical system has been preserved and described, thanks to M. Lambert; in all others there is only a large vacant space. The genus includes the former *Cyphosoma radiatum*, Sorginet (*subradiatum*), 1850, and its synonyms *C. simplex* and *C. spatulifera*, Forbes, and *C. perfectum*, Cotteau.

M. Lambert has founded a genus, or rather suggests the recognition of a genus of M. Pomel for *Cyphosoma pulchellum* and *C. Said* and many others.

In agreeing with M. Lambert's intelligent scheme, it is necessary to draw attention to M. Pomel's definition, which contains the statement that the upper part of the "interambulacrales" is more or less depressed "en gouttière" in the males, and hollowed



“en marsupium” in the females. This is not quite capable of verification; but it has nevertheless originated the name of a genus, *Thylechinus*.

Genus *THYLECHINUS*, *Pomel*, 1883, *Thèses, Class. Méth.* p. 91.  
*Lambert*, 1888, *Extr. Bull. Soc. d. Sci. Nat. de l'Yonne*, p. 11.  
 (Amended.)

Syn. *Cyphosoma* (pars), *Cott.*, Pér. et Gauth. 1881, *Éch. Foss. de l'Algér.* fasc. 8, p. 172, pl. xix. figs. 3-10 (*Cyphosoma Said*).

Test with a compact symmetrical apical system; radial plates excluded.

Ambulacral plates having three components and three pairs of pores in simple series only. Pairs of pores uniserial throughout; the interporiferous areas with two vertical rows of crenulated tubercles smaller than those of the interrada.

Interradia with two vertical rows of large primary tubercles crenulated. The median areas more or less depressed dorsally.

Peristome large; lips unequal; branchial incisions slight.

*Fossil.* Cretaceous: Europe, N. Africa.

For the generic position of *Cyphosoma Heinzi*, Pér. et Gauth., see p. 83.

### Division II.

The genus *Micropsis*, *Cotteau*, 1855-56, was diagnosed so as to include *M. Desori*, which has four vertical rows of ambulacral tubercles, and the pairs of pores in arcs of four; the interradaial plates very wide and rather low, with a primary tubercle and three small primaries on one side, and two on the other on each plate. There is no doubling of pairs, and the branchial incisions are small; but the number of coronal plates is great. It is like a *Coptosoma* with a considerable number of coronal plates.

A species, *Micropsis microstoma*, has three vertical rows of tubercles and five or six pairs of pores in arcs, to a plate. Again, *M. Leymerii* has only two pairs of vertical rows of tubercles and three pairs of pores to a plate. All the radial plates enter the apical ring. We do not understand how *M. globosa*, *Cott.*, and *M. leridensis*, *Cott.*, can be associated with the type species in the same genus. The *Micropsis* we described from the Nummulitic of Sind has many of the characters of, but the structure of the ambulacra differs from, *M. Cotteau's* type.

M. de Loriol (Ours. Tert. de la Suisse, Pal. Soc. Suisse, 1875, vol. ii. p. 16) considers *Micropsis* to be synonymous with the Cyphosomatoids with uniserial pairs of pores (*Coptosoma*); but the height of so many of the tests of *Micropsis*, the considerable number of the coronal plates, and the small size of the primary tubercles are distinctive. Nevertheless it is evident that not only are there species of *Coptosoma* in Cotteau's list of Micropsides, for instance *M. leridensis*, but some require elimination from the family, for instance *M. Vidali*, Cott., which is altogether aberrant.

The ambulacra of the species with four pairs of pores to a compound plate, such as the type species *M. Desori*, have not the component plates of their symmetrical compound plates arranged as in the genera *Cyphosoma* and *Coptosoma*; on the contrary, the arrangement resembles that of the species of *Placodiadema* (p. 64), which have numerous components to an ambulacral plate. The compound plate is high, and is composed of a small, low, broad adoral primary, very low at the median suture of the compound plate; or it may be a demi-plate; next comes a large primary, comprising most of the tubercles and the angle of the median suture; then succeed aborally, two low broad primaries, their adoral sutures being rather curved, convexity adorally. (See Quart. Journ. Geol. Soc. vol. xli. p. 431, fig. 8.) This arrangement may also occur when there are five pairs of pores to a compound plate; and then the last pair of pores is in a low broad primary, which resembles the aboral primaries of the other plate. This kind of arrangement is not seen in any species of *Cyphosoma*; and therefore there is a good physiological difference between the species with numerous pairs of pores and those with few which have been included in *Micropsis* and *Cyphosoma* or *Coptosoma*.

The species with three pairs of pores in an ambulacral plate may be grouped around *Micropsis venustula*, Dunc. & Sladen, 1884, Pal. Ind. ser. xiv., Foss. Ech. Sind, p. 119, pl. xxii. figs. 1-7. The apical system has large basal plates; a radial enters the ring, and the periproct is large and deformed; the ambulacra are narrow, and have two vertical rows of small perforate and crenulate primary tubercles and two vertical rows of secondary tubercles; the plates are high and compound; the adoral plate is a large primary carrying the bulk of a tubercle, and the other plates, placed aborally to it, are low broad primaries. The difference

between this arrangement and that already noticed is that in the instance of the plates with more than three pairs of pores the adoral primary is added, as it were, to the compound.

The interradia have only two vertical rows of primary tubercles, very slightly larger than those of the ambulacra; and there are two vertical rows of small secondary tubercles.

*Micropsis Leymerii*, Cott., and *M. d'Orbignii*, Cott., appear to be associated with this Sindian species in a little group which is hardly worthy of more than a subgeneric title (see *Gagaraia*).

A new genus or subgenus is required for *M. Vidali*, Cott.; for as we define the species it is a *Psammechinus* with crenulate tubercles.

Having made these necessary remarks, we proceed to give the diagnosis of *Micropsis*, which is transitional between the Cyphosomatidæ and the Diadematidæ.

Genus MICROPSIS, Cotteau, 1855, *Éch. Foss. des Pyrén.*, *Bull. Soc. Géol. de France*, sér. 2, vol. xiii. p. 326; 1882, *Bull. Soc. Zool. de France*, vol. vii. p. 411. *Duncan and Sladen*, 1884, *Pal. Ind.* ser. xiv., *Foss. Ech. of Sind*, p. 119. (*Amended*.)

Test of variable size, circular or slightly polygonal in tumid marginal outline, tumid dorsally, subconical, subhemispherical or depressed, concave actinally.

Apical system flush, with a large periproct, large basals, and one or more of the radial plates may or may not enter the ring. Coronal plates rather numerous.

Ambulacra with small primary tubercles, perforated and crenulated, in two or more vertical rows; pairs of pores from three to five in number; plates compound; the aboral components low and broad, with adoral sutures convex adorally, and the adoral component a large primary carrying the tubercle; a low primary or a demi-plate may or may not form the lowest part of the combination.

Interradia with many or few vertical rows of primary tubercles and secondaries.

Peristome small; branchial incisions well developed. Spines slender, long, subcylindrical, striated longitudinally, sharp.

*Fossil*. Cretaceous: Europe. Eocene: Europe, Asia, Egypt.

Subgenus GAGARIA, *Duncan*.

Syn. *Micropsis* (pars).

Tests with two vertical rows of primary tubercles in each area,

and with only three pairs of pores in each compound ambulacral plate.

*Fossil.* Cretaceous : Europe. Eocene : Asia (Sind).

The specific type is *Gagaria (Micropsis) venustula*, Dunc. & Sladen, 1884, Pal. Ind. ser. xiv., Foss. Ech. W. Sind, pt. iii. p. 119, pl. xxii. figs. 1-7, from the Nummulitic.

M. Lambert, 1888, Bull. Soc. d. Sci. Nat. de l'Yonne (extrait), contains some excellent remarks bearing upon M. Pomel's subdivision of *Cyphosoma*.

#### VI. Family ARBACIIDÆ, Gray. (*Amended.\**)

Test moderate in size, subhemispherical or subconical, depressed dorsally, flat actinally; epistroma with granules, projecting ridges, grooves, sessile glassy knobs, elongate or rugose, and tall, especially on the bare dorsal interradial median areas.

Apical system large; the periproct oval and oblique; the periproctal plates four, rarely more, triangular; the radial pores adoral, double.

Ambulacra straight, narrow, expanding near the peristome; pairs of pores simple or in large arcs, or crowded actinally; the plates compound near the ambitus, the middle component a large primary; the adoral and aboral being demi-plates with very curved sutures, their direction being nearly vertical towards the ambulacral median line; or the primary is adoral and the demi-plates are aboral to it.

Interradial plates with several or few vertical series of primary imperforate, non-crenulated tubercles, usually larger than those of the two rows of the ambulacra; with expanded bosses. Tentacles heteropodous. Spheridia solitary or numerous.

Peristome large, incurved at the sides of the ambulacra, and with branchial tags. Teeth keeled. Jaws with the pyramidal foramen open above. Plates united along the vertical sutures by dowelling, some of the projections may be large and lamellar.

Genus *Arbacia*.

*Echinocidaris* (gen. nov., non auct.).

*Cœlopleurus*.

*Podocidaris*.

\* For the structures noticed in this definition, see Duncan and Sladen, Journ. Linn. Soc. vol. xix. 1885, pp. 25 *et seq.*; and Lovén, 1887, Ech. descr. by Linnæus, pp. 80 *et seq.*

Genus ARBACIA, Gray, 1835, *Proc. Zool. Soc.* p. 58. *Troschel*, 1872, *Arch. f. Naturg.* vol. xxxviii. p. 293; 1872, vol. xxxix. p. 308. *A. Agassiz*, 1874, *Revision*, pp. 263, 399. *Bell*, 1879, *Proc. Zool. Soc.* p. 436. *Duncan & Sladen*, 1885, *Journ. Linn. Soc.* p. 48. *Lovén*, 1887, *Ech. descr. by Linnæus*, p. 80. (*Amended.*)

Syn. *Echinocidaris*, Desmoulins, 1835, Lütken, 1863; *Agarites*, Agassiz, 1841; *Pygomma*, Troschel, 1873.

Test moderate, thick, subcircular at the tumid ambitus, sub-hemispherical, depressed dorsally, flat actinally.

Apical system large, prominent; basals projecting into the interradia, long; radials entering or not the ring, the pore adoral double; all plates ornamented with epistroma; periproct oval, oblique, with four triangular periproctal plates (sometimes three to five).

Ambulacra straight, narrow to the ambitus and larger there and at the peristome and with a projecting lip; poriferous zones moderately narrow, and the pairs of pores in simple pairs dorsally, then in arcs of three and polyserial at the peristome; plates low primaries dorsally, then compound with a large median plate and an adoral and an aboral demi-plate, their inner sutures nearly vertical and curving upon the tubercle. Tentacles heteropodous.

Interradia with bare median dorsal areas near the apex, elsewhere with from three to seven vertical rows of plain primary tubercles on each side of the median line, more or less oblique, larger than those of the two vertical rows of the ambulacra, all diminishing in number and size dorsally. Epistroma greatly developed. Secondary tubercles absent.

Peristome large, tags or lamellæ for the branchiæ; ten buccal plates. Perignathic girdle with ridges, the ambulacral processes moderate but not arched. Jaws with the foramina of the pyramids open; teeth with a keel. Spines long, moderately stout, some spathiform, cellular within, may have a "cap." Pedicellariæ, some with large glands on their stalks. Plates of the test united at the vertical sutures by partial dowelling, some of it coarse. A solitary spheridium in each ambulacrum in a large pit.

*Fossil.* N. America, Tertiary? (The European Miocene species is a *Psammechinus*.)

*Recent.* Florida, Caribbean Sea, Long Island to Yucatan, Brazil, Straits of Magellan, Patagonia, Chili, Peru, Panama,

California, Kerguelen, Philippines, W. coast of Africa, Canaries, Cape de Verd Is., Azores, Mediterranean.

Genus ECHINOCIDARIS, gen. nov. (*non Desmoulins*). *Duncan & Sladen*, 1885, *Journ. Linn. Soc.* vol. xix. p. 53. *Lovén*, 1887, *Ech. descr. by Linnæus*, pp. 81 & 95.

Syn. *Arbacia* (pars). (*Echinus niger*, *Molina*.)

Test regularly arched, circular in ambital outline, much wider than high, gibbous in the interradia at the ambitus. Some radial plates enter the oblique, elongate periproctal ring, and are usually small or as little knobs; periproctal plates normally four.

Ambulacra narrow abactinally, and very wide at the peristome; two rows of plain primary tubercles, separated by miliaries; plates, when compound, consisting about the ambitus, of four or five components, a large primary plate being adoral, the others all demi-plates, with more or less vertical inner sutures, are aboral. Pairs of pores polyserial at the peristome.

Interradia with high coronal plates above the ambitus, each with a large tubercle near the poriferous zone, and four smaller which extend towards the median suture, and are near the adoral sutures; minute secondary tubercles placed above the primaries. Near the peristome the plates are low, and there are many vertical rows of primaries, packed closely and without very definite order.

Peristome large, interradiial ends very small, branchial cuts broad. One large pit for a single spheridium in each ambulacral median line near the peristome. Spines short on the dorsal part of the test except along the poriferous zones, where they are long. Tentacles heteropodous. Epistroma moderate.

The union of the vertical median sutures, and also between the ambulacra and interradia, is by dowelling and dovetailing; some plates have lamellæ or triangular prominences on their edges and the opposed plate-edges are correspondingly holed.

*Recent.* Patagonia and Peru.

Genus CÆLOPLEURUS, *Agassiz*, 1840, *Cat. Syst. Ectyp. Ech.* p. 19. *Desor*, 1858, *Synopsis*, p. 96. *A. Agassiz*, 1874, *Revision*, p. 267. *Duncan & Sladen*, 1883, *Pal. Ind.* ser. xiv., *Foss. Ech. Kachh and Kattywar*, p. 53; 1884-85, *Sind, Nari series*, pp. 251 et seq.; 1885, *Journ. Linn. Soc.* vol. xix. p. 27.

Test moderate in size, tumid and more or less circular in out-

line at the ambitus; subconical or depressed dorsally, flattish actinally.

Apical system large, with an elongate periproct with four or more large triangular plates; basals large, united; radial plates with a double perforation on the adoral edge.

Ambulacra narrow, with two vertical rows of primaries on flat scrobicules with well-developed bosses and mamelons, imperforate and non-crenulate, diminishing in size towards the apex and sometimes replaced there by granules. Poriferous zones narrow; pairs of pores in arcs near the ambitus and abactinally, some on the flanks of the tubercles, becoming slightly crowded actinally. Plates, primaries near the apex and becoming triple compound plates near the ambitus, consisting of a middle large primary plate and adoral and aboral short demi-plates; the sutures of the demi-plates and the middle primary bent on the flanks of the tubercle and then directed vertically adorally and aborally. Tentacles heteropodous.

Interradia with a large bare ornamented median area abactinally, and having the primary tubercles largest at the ambitus and diminishing in size towards the apical system or disappearing, placed on flat scrobicules, imperforate, and without crenulation, surrounded with granules.

Peristome with small branchial incisions and long tags; buccal membrane rugose near the teeth, with 10 small buccal plates, covered with pedicellariæ and with large disked tentacles, otherwise the membrane is bare. Perignathic girdle slender, ridges broad and low; the ambulacral processes moderate and usually arched. Teeth keeled. Dowelling occurs between the apical plates and between the interradial plates. Pits with spheridia at the median sutural junctions of the ambulacral plates near the peristome. Pedicellariæ with glandular stems.

The epistromal ornamentation very generally developed; the furrows and ridges and long lines of granules elongate or not, and in zigzag, by the side of and across the interradial bare spaces, and S-shaped bands occur in some species; the apical system also ornamented. Spines long, curved, more or less triangular in outline, cellular within, those of some primary tubercles very long, some spathulate.

*Fossil.* Eocene: England, Europe, N. America. Oligocene and Miocene: Europe, Asia.

*Recent.* Florida, the Caribbean Sea, Bourbon, Philippines, Amboyna, Indian Archipelago.

Genus *PODOCIDARIS*, *A. Agassiz*, 1869, *Bull. Mus. Comp. Zoöl.*; 1872, *Revision*, p. 269; 1881, *Report on 'Challenger' Ech.* p. 59; 1883, *Report on 'Blake' Ech.* p. 22.

Test moderate in size, pentangular or circular in tumid marginal outline, regularly arched but depressed abactinally, faintly tumid actinally around the large depressed peristome.

Apical system with large basal and radial plates; periproct small, with four or five triangular plates; anus at their inner points.

Ambulacra rising above the general level, broadest at the ambitus, and about equalling the interradia at the peristome. Primary tubercles plain, seen at the ambitus and actinally only, the rest of the interporiferous area being furnished with short sessile spines, with or without pits at their bases. Pairs of pores in simple series.

Interradia broad at the ambitus, and having the primary tubercles at the ambitus and actinally, the rest of the surface with sessile spines similar to those of the ambulacra.

Peristome large, pentagonal, depressed, with branchial incisions. Tentacles prehensile from the peristome to above the ambitus, and pointed and branchial abactinally. Peristomial membrane with buccal plates. Articulated spines restricted to the ambitus and under surface of the test, short and fusiform, or long and slender, striated, serrate, others without a socket and continuous with the test.

*Recent.* Caribbean Sea, 150 to 590 fathoms, and Philippines, 1050 to 1075 fathoms.

## VII. Family TEMNOPLEURIDÆ.

Regular, ectobranchiate gnathostomes, with the teeth keeled, the pyramids of the jaws having epiphyses closing the foramen, the external branchiæ tufted or dactylose; the ambulacra with triple compound plates and subhomoiopodous tentacles; the suture of the ambulacral and interrarial plates and of the apical system grooved and may be pitted, or there may be a raised ornamentation, costulate or reticulate or in ridges, the sutures being furrowed or not. Plates united by dowelling.

### Subfamily *Glyphocyphinæ*.

Tumid tests with a large apical system, the basals low, and



either some or all the radial plates entering the periproctal ring, or the system is compact. Ornamentation raised, costulate or reticulate, with or without sutural furrows; sutural pits absent.

Subfamily *Temnopleurinae* (p. 106).

Tumid or spheroidal tests with a compact apical system, the sutures grooved and pitted, "undermined" or not, the plates highly ornamented and united by dowelling.

Subfamily *Glyphocyphinae*.

This subfamily may be divided artificially, into genera with large apical systems into the ring of which some radial plates enter, and into genera with solid apical systems.

- Genus *Glyphocyphus*.
- Dictyopleurus*.
- Arachniopleurus*.
- Ortholophus*.
- Paradoxechinus*.
- Echinocyphus*.
- Zeuglopleurus*.
- Lepidopleurus*.
- Leiocyphus*.
- Coptophyma*.
- Trigonocidaris*.

Genus GLYPHOCYPHUS, *J. Haime*, 1853, *Anim. foss. de l'Inde*, p. 208. *Desor*, 1858, *Synopsis*, p. 102. *Cotteau*, 1859, *Éch. du Dépt. de la Sarthe*, p. 158, pl. xxviii.; 1862-67, *Pal. Franç.*, *Terr. Crét.* vol. vii. p. 531; *Bull. Soc. Zool. de France*, 1886, p. 86. *Duncan & Sladen*, 1882, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, p. 36.

Test small, more or less tumid at the ambitus, broader than high, depressed spheroidal. Coronal plates moderately numerous. Epistroma highly developed.

Apical system large, all the basals and radial plates entering a narrow periproctal ring; madreporite small, punctures distinct; pore of the radial plates adoral; periproct large, elongate, ovoid.

Ambulacra narrow, straight, with two vertical rows of small,

perforate, crenulate, primary tubercles, largest actinally; boss spreading, mamelon globose and prominent, placed upon the aboral third of a plate; miliaries abundant, those nearest the tubercle elongate, and radiating more or less towards other miliaries which encircle them, arrangement confused further away. Plates high, compound, usually three pairs of pores and rarely four to a compound plate, almost in straight series or slightly in arcs; component plates are low, broad primaries with straight transverse sutures. On the tumid actinal surface a few large tubercles exist and sometimes alternate; they have distinctly radiating, long miliaries, resembling short costæ, between the boss and the usual circle of miliaries.

Interradia broad, with two vertical rows of primary tubercles, resembling, but slightly larger than, the ambulacral; a few secondary tubercles may exist; miliary tubercles numerous, irregularly placed near the edges of the plates, in circles around the bosses and united to them by more or less elongated ridges; a costa-like projection, or several, placed adorally to the primary tubercles, arising from them or from the adoral edge of a circle of surrounding miliaries, and thence extending to, or over, the adoral coronal suture of the plate. Tubercles and their surrounding radiations and circle of miliaries largest and most distinct actinally.

Ambulacral and interradial transverse sutures grooved, especially actinally to the tubercles, and the median sutures also.

Peristome small, sunken, with very slight branchial incisions.

*Fossil.* Cretaceous: England, Europe, and N. Africa. Middle Eocene: Europe. Upper Tertiary?: Europe.

A comparison of the drawings of *Glyphocyphus radiatus*, Höning, sp., in the works of Desor, Cotteau, and Wright will satisfy most students that either the variation of characters must be considerable or the details of structure have been drawn from indifferent specimens. Having had the advantage of examining perfect specimens, some of which are in the National Collection, it appears that the amount of variation is not great. It amounts to a stouter condition of the invariably narrow apical ring around the large periproct, especially of the anterior plates, the presence of an extra pair of pores in some ambulacral plates, a larger development of the ambulacral tubercles actinally, and the presence or absence of one or more short costa-like projections, placed adorally to each interradial tubercle. The grooving of the transverse sutures of the interradial coronal plates is not

a simple deepening along the line of suture, for the furrow is broad. In every specimen there is more of the radiation of the miliaries from a tubercle than is given in any drawing hitherto published, and the miliaries are much more crowded and irregular in shape than has been figured.

The raised nature of the epistromal ornamentation is seen around the spaces which occur along the transverse and the vertical sutures in well-preserved British specimens; it gives a very Temnopleurine appearance to the test. The figure given by Cotteau, *Pal. Franç.* vol. vii. pl. 1128, figs. 16-22, of *G. rugosus* shows the tubercles with four or five costæ projecting adorally instead of one, and recalls *Opechinus*, Desor. The sutures in this species are partly, but well grooved near the angles of plates.

Genus *DICTYOPLEURUS*, *Duncan & Sladen*, 1882, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, p. 38.

Test small, hemispherical above, slightly concave actinally, more or less turban-shaped. Epistroma well developed.

Apical system: periproct oblique, elongate, elliptical, with a raised edge; basals unequal, with depressions between the foramina and the ring; radial plates large, some enter the narrow ring.

Ambulacra narrow, straight, pairs of pores in straight series; tubercles of the interporiferous area very small, in two vertical rows close to the poriferous zones, indistinctly crenulate and perforate, united by a zigzag of raised broad or narrow ridges. Each tubercle is connected with two of the opposed row, and with the tubercles placed above and below, by a raised rib-like ornamentation.

Interradia broad, with two vertical rows of primaries resembling those of the ambulacra, but more distinctly perforate and crenulated, united with those of the opposed row by a broad or narrow oblique or longitudinal, raised, granulated or not, series of costæ, and with the tubercle immediately above and below by means of a narrow vertical costa; the tubercles are raised above the common level. The sutural lines between the plates of both areas are visible, and are plain and not sunken.

Peristome small, and the branchial incisions also.

*Fossil.* Eocene: Asia (W. Sind), Africa (Egypt).

Genus ARACHNIOPLEURUS, *Duncan & Sladen*, 1882, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, p. 42.

Test depressed, tumid at the circular ambitus, rising but slightly abactinally. Epistroma well developed. Apical system large, defective.

Ambulacra narrow; pairs of pores in slight arcs, penetrating ridges which are continuous with radiating costæ coming from the scrobicular circle of the raised, small, perforate, crenulate tubercles of the interporiferous area. Tubercles of both areas in two vertical rows, each on a raised scrobicule from which radiate costæ, and the ends of these are surrounded by a circle of raised rib-like structure, carrying large granules. The circle gives off radiating costæ externally, some of which reach the circles of the opposed row of tubercles and others pass to the poriferous areas. Vertically the circles are more or less in apposition. Plates and sutures visible between the raised ornamentation.

Peristome small, deeply seated; branchial incisions small.

*Fossil*. Eocene: Asia (Sind).

Genus ORTHOLOPIIUS, *Duncan*, 1887, *Quart. Journ. Geol. Soc.* vol. xliii. p. 414.

Test small, low, more or less pentagonal in marginal outline, subconical above the tumid ambitus. Epistroma well developed.

Apical system wanting. Periproct small and circular.

Ambulacra half of the width of the interradia at the ambitus, straight, with slightly sunken poriferous zones; pairs in ill-defined triplets, nearly in straight series, appearing on the actinal flanks of the costulation. Compound plates made up of a middle demi-plate and an adoral and aboral primary. A vertical row of small imperforate, non-crenulated primary tubercles is close to the poriferous zone in the interporiferous area; and the space between the rows is occupied by crowded, transverse, ridge-like costæ, passing from the opposite tubercles and carrying small secondaries.

Interradia with two vertical rows of primary tubercles, of the same size and shape as those of the ambulacra; their scrobicules raised, united with those placed actinally and dorsally by vertical, straight costæ, and with those of the opposite row by numerous crowded, transverse, straight costæ with small secondaries upon them.

Peristome small, almost without cuts.

*Fossil.* Australian Tertiaries (Mordialloc).

Genus PARADOXECHINUS, *Laube*, 1869, *Sitzungsab. d. kais. Akad. d. Wiss. Wien*, Bd. lix. p. 186, fig. 2. (*Amended.*)

Syn. *Coptechinus*, *Cotteau*, 1883.

Test small, depressed, much broader than high, tumid at the ambitus and slightly pentagonal in marginal outline, flat actinally. Epistroma well developed.

Apical system wanting, but was large, wide, and circular.

Interradia moderately broad, with a vertical row of primary tubercles near the ambulacra; the successive tubercles are united by a narrow fillet or ridge on which are two rows of small secondaries or large granules, and there is a zigzag of fillets composed of double rows of similar secondaries or granules between the opposite vertical rows of primary tubercles; moreover a zigzag exists, of corresponding structure, between the interradial and the ambulacral tubercles.

The ambulacral primaries are in two rows placed vertically, and there is a zigzag of raised fillets between them as in the interradia. The width of the ambulacra is very slightly less than that of the interradia, and the primary tubercles of both areas are subequal, smooth and non-crenulated. The test is deep and flat between the fillets, and the pairs of pores, three to a plate, in the ambulacra are on the deep part of the test and more or less in grooves.

The peristome is pentagonal, and the branchial cuts are slight.

*Fossil.* Miocene of Murray Cliffs, S. Australia.

Laube described one species, *P. novus*, and the dimensions of the specimen are important. Height 6.5 millim., diameter 13 millim., diameter of the apical scar 7 millim., diameter of peristome 4 millim. It is evident that the apical system was large, and from Laube's figure it would appear that all the radials reached between the basals to the periproct.

Cotteau has defined a genus *Coptechinus*, 1883, "Éch. nouv. ou peu connus," *Bull. de la Soc. Zool. de la France*, vol. viii. p. 456, from the Miocene of France, and it is synonymous with *Paradoxechinus*, Laube.

Genus ECHINOCYPHUS, *Cotteau*, 1859, *Éch. du Dépt. de la Sarthe*, p. 226, pl. xxxix. bis. fig. 6; 1862-67, *Pal. Franç. Terr. Crét.*

vol. vii. p. 707. *Wright*, 1870, *Pal. Soc., Monogr. Brit. Cret. Ech.* vol. i. pt. iii. p. 116. *Gregory*, 1889, *Ann. & Mag. Nat. Hist.* ser. 6, vol. iii. p. 490. (*Amended.*)

Syn. *Glyphocyphus* (pars).

Test small, tumid in circular or subpolygonal marginal outline, depressed, subconical or tumid dorsally, tumid actinally. Epistroma well developed.

Apical disk small, with the antero-lateral basal plates narrow and united; postero-lateral basals moderate in size, united to the antero-lateral basals, and meeting anteriorly to the periproct. Posterior basal absent in the type, but its impression left between the postero-lateral radial plates, both of which enter the periproctal area, denotes that it was broad from side to side and low. The anterior and antero-lateral radial plates are excluded. Periproct oval in shape, somewhat posterior.

Ambulacra straight, narrow, with some high plates placed abactinally to very low ones; two vertical rows of imperforate, crenulate, primary tubercles; mamelon globose, boss expanded, small abactinally, largest below the ambitus, where sometimes one may occupy nearly all the breadth of an ambulacrum; surrounded by stout and irregularly placed miliaries, or by compressed ridges which radiate from the tubercles. Poriferous zones narrow, pairs in very slight arcs, usually in triplets, and then the plate is made up of three low primaries with straight transverse sutures; or with four or even five pairs, but then the fourth and fifth pairs are in low primary plates independent of the high compound one. There may be some grooving of the ambulacral sutures and a continuity of ridges between the elevations, on which pairs of pores are placed, and ridges coming from the circular rows of miliaries around the interrarial tubercles.

Interradia with two vertical rows of primary tubercles slightly larger than, but otherwise resembling, those of the ambulacra; miliaries radiating from the primaries compressed from side to side, or tear-shaped. The larger tubercles are actinal, and usually they have a circle of granules around the radiating series of compressed miliaries. Transverse coronal sutures simply and narrowly grooved.

Peristome small, sunken, with very small branchial incisions.

*Fossil.* Cretaceous: England, Europe.

Genus ZEUGLOPLEURUS, *Gregory*, 1889, *Ann. & Mag. Nat. Hist.* ser. 6, vol. iii. p. 494.

Syn. *Echinopsis* (pars); *Echinocyphus* (pars); *Glycocyphus* (pars).

Test small, globular, depressed below, slightly conical above; sides tumid. Epistroma well developed.

Apical disk somewhat solid, the two postero-lateral radial plates enter the periproctal ring; the antero-lateral pair of basal plates meet the adjoining basals, and thus the antero-lateral and anterior radial plates are excluded from the ring, while the periproct is pushed towards the posterior end; the posterior basal is very narrow. All plates perforated by the madreporite.

Ambulacra somewhat narrow and straight. Each bears two rows of primary tubercles, which are slightly smaller than those of the interradia, and are crenulate, imperforate, and surrounded by small scrobicules, broken by series of radiating costulate ridges which unite with those of the adjoining plates above and below; the rest of the plate with miliary granules arranged with some regularity. The horizontal sutures are notched with grooves much as in *Glyphocyphus*, which affect especially the adoral edge of the plate, so that the lower plate projects above the upper one. In the poriferous zones the pairs of pores are in single and nearly straight vertical rows; the plates nearest the apex are primaries; but proceeding actinally they become fused to compound plates of two or three primaries; a single primary is often intercalated between two compound plates.

Interradia one and a half times as wide as the ambulacra; the epistroma similar to that upon the ambulacral plates, but more developed. A single vertical row of primary tubercles on each side of each interradium; the tubercles larger than those of the ambulacra and connected by costulate ridges, and the rest of the plate is covered with very close miliary granules; a small row of secondary tubercles may be developed in the aboral external corner of each plate. Tubercles imperforate and crenulate.

Peristome about equal to the apical disk in size; branchial slits small.

*Fossil.* Cretaceous: England, Europe.

The type is *Zeuglopleurus costulatus*, Greg.

Genus *LEPIDOPLEURUS*, *Duncan & Sladen*, 1885, *Monogr. Foss. Ech. W. Sind, Pal. Ind.* ser. xiv. p. 306.

Test small, nearly hemispherical or turban-shaped.

Apical system large, solid; basal plates large; radial plates excluded from the ring, their pores adoral. Epistroma moderate.

Ambulacra small; poriferous zones slightly sunken, pairs of pores in simple series of triplets; plates composed of an aboral and larger adoral primary with an intermediate demi-plate; near the apical system are a few low primary plates. Interporiferous area crossed by a zigzag of raised granular ridges, uniting the tubercles.

Interradial plates scale-like, with the adoral edge overlapping a corresponding depression on the aboral edge of the actinally placed plate; two vertical rows of primary, plain tubercles connected by narrow, vertical ridges.

Peristome small, and the branchial incisions small. Transverse sutural lines sunken.

*Fossil.* Miocene: Asia.

Genus *LEIOCYPHUS*, *Cotteau*, 1866, *Pal. Franç., Terr. Crét.* vol. vii. p. 760, 1862-67.

Test small, circular at the ambitus, tumid dorsally, almost flat actinally.

Apical system narrow, not solid (judging from the shape of the space).

Ambulacra with narrow poriferous zones, with simple series of pairs of pores throughout; plates compound, and in triplets of primaries. Tubercles of both areas nearly equal, plain, subscrobiculate, somewhat elongated at the ambitus and dorsally, but losing this character actinally. Secondary tubercles compressed and elongate in the vertical direction abactinally, globular actinally. Coronal interradian plates moderate in number (14), with more or less deep grooves in the horizontal sutures.

Peristome small; branchial incisions very small.

*Fossil.* Cretaceous: Europe.

Genus *COPTOPHYMA*, *Péron et Gauthier*, 1879, *Éch. foss. de l'Algérie*, fasc. 5, p. 209, pl. xv.

Test small, tumid at the circular ambitus, subdepressed dorsally and flat or slightly tumid actinally.

Apical system well developed, with five large basals completing the large pentagonal periproctal ring; radial plates large.



Ambulacra narrow, with granules only in the interporiferous areas, some having mamelons. Pairs of pores in low, broad primary plates and in simple series abactinally and at the ambitus; actinally the series also persists, but there is a small demi-plate intercalated close to the median ambulacral suture actinally to large granules. This plate is sunken and has a pair of pores, but probably is not in connexion with the ambulacro-interradial suture.

Interradia with two rows of vertically placed, large, crenulated, imperforate tubercles, and no secondary tubercles. The transverse sutures below the tubercles are deeply grooved, the base of the tubercles being affected.

Peristome subcircular, with branchial incisions; the ambulacral lips as large as those of the interradia.

*Fossil.* Cretaceous: N. Africa.

Genus TRIGONOCIDARIS, *A. Agassiz*, 1869, *Bull. Mus. Comp. Zool.* vol. i.; 1872-74, *Revision*, p. 289; 1881, '*Challenger*' *Report*, p. 111.

Test small, thin, regularly arched above, circular in marginal outline, depressed actinally. Epistroma moderate.

Apical system ornamented or not, with very large basal plates, excluding the radial plates from the elongate periproct, which is covered by four plates, one being much the largest.

Ambulacra with two principal vertical rows of plain primary tubercles, united together by a reticulation of raised ornamentation, producing the appearance of ridges and furrows; pairs of pores in straight series.

Interradia with rows of plain tubercles slightly larger than those of the ambulacra, and joined by the same kind of ornament; sutures of the plates either in the furrows between the ridges or not visible; small secondary tubercles may be amongst the variable ornamentation.

Peristome with slight branchial incisions, the actinal membrane with ten buccal plates and others which imbricate. Spines moderately long, slender, striated.

*Recent.* Florida, Caribbean Sea; Josephine Bank; Kermadec Islands.

The genus requires more careful working out, and from the present knowledge of the species it should be classified with the *Glyphocyphinae*, but it has alliances with the *Temnopleurinae*.

Subfamily *Temnopleurinae* (p. 97).Genus *Temnopleurus*.Subgenus *Pleurechinus*.Genus *Temnechinus*.*Salmacis*.Subgenus *Salmacopsis*.Genus *Mespilia*.*Microcyphus*.*Amblypneustes*.*Goniopneustes*.*Holopneustes*.Genus incertæ sedis: *Grammechinus*.

Genus TEMNOPLEURUS, Agassiz, 1841, *Monogr. Éch. viv. et foss.*, *Preface to Valentin, Anat. Gen. Echinus*, p. 7. Herklots, 1854, *Foss. de Java (Leide)*, p. 4, pl. i. Desor, 1858, *Synopsis*, p. 104. A. Agassiz, 1874, *Revision*, p. 460. Martin, 1880, *Rev. Foss. Ech. Java, Notes Leyd. Mus.* vol. ii. pp. 73-85. J. Bell, 1880, *Proc. Zool. Soc.* p. 422. Duncan & Sladen, 1883, *Pal. Ind.* ser. xiv., *Ech. Kachh & Kat.* p. 54. Duncan, 1883, *Journ. Linn. Soc.* vol. xvi. p. 350; 1888, *Ann. & Mag. Nat. Hist.* ser. 6, vol. i. p. 109.

Test stout, small and moderate in size, circular or slightly pentagonal at the tumid ambital outline, subconical and depressed abactinally, tumid and reentering around the small peristome. Coronal plates moderately numerous, with much epistroma.

Apical system small, compact, slightly projecting; basal plates thick, mostly united, the largest the right anterior containing the madreporite, which has circular pores; all have secondary tubercles for spines and a rather large genital perforation. Radial plates small, excluded, or one may enter, tumid, broad at their actinal edge and ornamented above with miliaries and small tubercles for pedicellariæ and spines. Pore situated adorally and divided externally by a vertical septum; furrows over the sutures and a deep pit actinally to each radial plate. Periproct variable in size and in the number and size of its plates\*.

Ambulacra straight, narrow; pairs of pores in slight arcs of threes, the inner pore of a triplet the adoral; plates rather high, compound, made up of a large adoral primary containing the adoral

\* See the variations shown on pl. viii., A. Agassiz, *Revision*, in *T. Hardwickii* and *T. Reynaudi* and compare with *T. toreamaticus*.

pair of pores, of a small demi-plate with the middle pair of pores, and an aboral low, wide primary with the aboral pair of pores of the triplet. Two vertical rows of well-developed primary tubercles in the interporiferous area, and large secondaries; some of the smaller secondaries and miliaries placed around the narrow depressed scrobicule of the primary tubercles, which have a large, conical, distinctly crenulate boss, and the well-developed mamelon is smooth and rounded. Tentacles stout and homoiopodous.

Interradia broad, with two vertical rows of primary tubercles resembling or slightly larger than those of the ambulacra, with numerous secondary tubercles arranged more or less around them, and miliaries; a process actinal to each tubercle.

All the plates of the test, except the component ambulacral plates, united by a dowelling of knobs and sockets. The transverse sutures of all plates grooved deeply and widely, either throughout their length or near the ends; deep pits at the angles of sutures and along the ambulacro-interradial sutures, undermining much of the test; pits large, in the ambulacral median line actinally and with large broad-topped spheridia.

Peristome small, branchial incisions very small, branchiæ narrow, dactylose; actinal membrane bare, only with ten small broad tentacular plates; perignathic girdle well developed, its foramen small, processes united. Pyramids of jaws with a tall foramen closed above by epiphyses; teeth keeled. Spines variable, moderate, slender, more or less compressed, striated, with a milled ring, sharp or blunt at the end, especially actinally. Many globiform pedicellariæ with short stalks and others with long stalks and long soft processes; similarly stalked small triphyllæ in great numbers.

*Fossil.* Tertiary: Java. Mekran Series: Persian Gulf. Subfossil: Red Sea.

*Recent.* Japan, Kamtschatka, Philippines, Arafura Sea, Mergui, Ceylon, China, E. Indian Islands, Persian Gulf, New Zealand.

Subgenus PLEURECHINUS, *Agassiz* (genus), 1841, *Monogr. d'Éch. viv. et foss.*, *Pref. to Valentin, Anat. Gen. Ech.* p. 8. *A. Agassiz*, 1873, *Revision*, p. 464; 1881, 'Challenger' Report, p. 10. *Martin*, 1880, *Rev. Foss. Ech. Java, Notes Leyd. Mus.* vol. ii. pp. 73-85. *Duncan*, 1883, *Journ. Linn. Soc.* vol. xvi. p. 447.

Test rather high, apical system highly ornamented, grooves of

the sutures often or not with regular deep portions, and the pits deep at the angles, or sutures deep and plain. Tubercles plain or indistinctly crenulated. Knobs and sockets of the dowelling few in comparison with *Temnopleurus*.

*Fossil*. Tertiary: Java.

*Recent*. Japan; Arafura Sea.

The genus *Opechinus*, Desor, 1858, Synopsis, p. 107, has several shallow pits in each transverse coronal suture, and its author considers that there are recent and fossil species; amongst the first he instances none, but probably meant to refer to *Pleurechinus*; in enumerating and describing the fossil forms he mentions the so-called *Temnopleuri* of the Nummulitic of Sind. It has been shown (Duncan & Sladen, Pal. Ind. ser. xiv., Foss. Ech. of Sind, 1882, pt. ii. p. 36, and same series Ech. Kachh & Kattywar, 1883, p. 54) that the forms described by d'Archiac and Haime were not from the Nummulitic, but from the higher Tertiaries, and that they could not be separated from *Temnechinus*, Forbes. But it is quite evident that several of the *Temnechini*, when rolled and weathered, show several shallow pits along the transverse sutures. All the specimens seen by d'Archiac and Haime were in a most wretched condition, and are still in the museum of the Geological Society of London.

We do not consider that *Opechinus* is a good genus.

GENUS TEMNECHINUS, Forbes, 1852, Pal. Soc., Monogr. Brit. Tert. Ech. p. 5. Desor, 1858, Synopsis, p. 105. A. Agassiz, 1872-74, Revision, p. 285; 1883, 'Blake' Echin. p. 37. Duncan & Sladen, 1883, Pal. Ind. ser. xiv., Ech. of Kachh &c. p. 57. Syn. *Opechinus*, Desor.

Small or moderate-sized tests, subglobular, depressed abactinally. Epistroma moderate.

Apical system prominent, sutures between the plates more or less grooved; a large periproctal plate and a few small anal ones\*.

Ambulacra with a slightly undulating series of pairs of pores; pairs in triplets, the middle pair in a demi-plate, the adoral component a large primary, the aboral component a smaller primary; two vertical rows of small plain primaries in the interporiferous area. Interradia with primaries resembling those of the ambulacra but larger; some secondaries. Transverse sutures of

\* This refers to *T. maculatus*, A. Ag., the recent species.

coronal plates variously and more or less deeply furrowed; grooves at the angles.

Peristome moderate, with branchial incisions; processes of perignathic girdle slender and closed above. Teeth keeled. Spines short and slender. (Occasionally a true pit, but not undermining the test, is seen at a sutural angle, and a crenulate tubercle is very rarely visible.)

*Fossil.* Miocene: W. Sind, Kach, Kattywar. Pliocene: England. Mekran Series: Persian Gulf.

*Recent.* Caribbean Sea, Florida; Azores; Josephine Bank. 30 to 600 fathoms.

It has been shown, Duncan & Sladen, Pal. Ind. ser. xiv., Ech. Kachh &c. p. 54 *et seq.*, that MM. d'Archiac and Haime were misinformed regarding the Nummulitic distribution of the *Temnechini* of Sind, and that the forms they described in 'Les Animaux foss. de l'Inde' as *Temnopleuri* were *Temnechini*. The habitat was clearly on a Miocene horizon.

Genus SALMACIS, Agassiz, 1841, *Monogr. d'Éch. viv. et foss.*, Preface to *Valentin, Anat. du Gen. Ech.* p. 8. Desor, 1858, *Synopsis*, p. 108. A. Agassiz, 1872-74, *Revision*, p. 471. J. Bell, 1880, *Proc. Zool. Soc.* p. 422. Duncan, 1883, *Journ. Linn. Soc.* vol. xvi. p. 345; 1888, *Ann. & Mag. Nat. Hist.* ser. 6, vol. i. p. 109. Ramsay, 1885, *Cat. Ech. Austr. Mus.* p. 47.

Test varying in size and shape, moderate and large, circular or subpentagonal in tumid ambital region, broader than high, subconical, globose abactinally, flattish or tumid actinally. Coronal plates numerous, low and broad.

Apical system moderate or small, the basal plates uniform except that bearing the madreporite, which is the largest, tuberculate around the ring, excluding or not some of the radial plates; sutures distinct. Periproctal membrane with small plates, some polygonal and carrying small spinules and small globiform pedicellariæ.

Ambulacra straight; poriferous zones broad, with small secondary tubercles; pairs of pores biserial in close but decided arcs of triplets, the middle pair of pores being nearest the ambulacro-interradial suture and in a demi-plate. The plates compound, broad and low, adoral component a large primary, the middle a demi-plate, the aboral a small low primary. Primary tubercles crenulate and imperforate, those of the interporiferous

zones largest and most numerous actinally, two rows reach the apex; secondary tubercles and granules exist; scrobicules small, raised or not.

Interradia much broader than the ambulacra, with numerous vertical rows of primaries, resembling those of the ambulacra, diminishing in number and size abactinally and allowing a broad median space to exist; secondaries and miliaries exist.

Plates of both areas with their lines of suture narrowly grooved, with small but well-defined, oblique, deep pits at the angles of junction of all plates, and along the ambulacro-interradial vertical sutures. Sutural edges of plates well dowed.

Peristome small, subdecagonal, branchial incisions small. Branchiæ moderately large, with a stout base and bunches of finger-shaped processes. Perignathic girdle with well-developed ridges and tall processes, expanding above, united, and with a variably sized foramen. Foramen of the pyramids with a closed arch; teeth keeled. Peristomial membrane rugose near the teeth, plain elsewhere; ten buccal plates with large tentacles and small stalked pedicellariæ.

Tentacles subhomoiopodous, for the abactinal are very wide and long, feeble in muscular structure, yet the sucker-ring exists and is small; actinal and ambital tentacles disciferous. Spines short, delicate, striated, some sharp, others flat-ended.

*Fossil.* Eocene: Europe. Pliocene, Mekran Series: Persian Gulf.

*Recent.* Red Sea, Indian Ocean, Persian Gulf, Mergui, Philippines, Japan, Siam, Australian seas, E. coast of Africa.

Subgenus *SALMACOPSIS*, *Döderlein*, 1885 (genus), *Archiv für Naturg. Wieg. Berlin*, Heft i. p. 93.

Test much broader than high, circular in ambital outline. Coronal plates high; tubercles few, small and smooth. Abactinally the plates near the median line are smooth. Pits sharp and angular, in the median line. Pores simple. Spines as in *Salmacis*.

*Recent.* Sigambai, Japan, 100-150 fathoms.

This is evidently a subgenus of *Salmacis*.

Genus *MESPILIA*, *Desor*, 1846, *Agass. & Desor, Cat. Rais., Ann. Sci. Nat.* p. 357; *Synopsis*, 1858, p. 110. *A. Agassiz*, 1872-74, *Revision*, p. 477. *J. Bell*, 1880, *Proc. Zool. Soc.* p. 434. *Duncan*, 1888, *Ann. & Mag. Nat. Hist.* ser. 6, vol. i. pl. xi. fig. 5, p. 113.

Test moderate in size, thin, more or less globular or oblatly

spheroidal and depressed, broader than high. Coronal plates numerous.

Apical system with a large periproct; the membrane with numerous plates, which are tuberculate; ring narrow, genital foramina large; basal plates broad, pentagonal, the madreporite distinct and in the largest; radial plates broad, excluded. Coronal plates numerous, low and broad.

Ambulacra moderate in width; poriferous zones broad; tubercles very small, placed near the poriferous zones only, abactinally, and closely packed throughout actinally. Median area broad, bare of primary tubercles, with pedicellariæ and granules; poriferous zones broad, with the pairs of pores in very close triplets, appearing to be biserial; the inner vertical row of pairs of pores the most numerous, formed by the adoral and aboral pairs of a triplet being nearly in vertical series; the middle pairs of pores are in the outer vertical row, each pair in a demi-plate, which is placed close to the ambulacro-interradial suture. Plates compound, low, broad; the adoral a large primary, the middle a small demi-plate, and the aboral constituent a small low primary.

Interradia broad, with a broad, bare, median space, bounded on either side by a belt of several close vertical rows of small tubercles resembling those of the ambulacra; actinally the tubercles are close and cover the plates. Sutures of the median series finely grooved in both areas; pits small, at the median angles. Dowelling occurs.

Peristome moderate, decagonal; branchial incisions small but broad, and with a lip. Perignathic ridges low, processes high, connected, foramen large. Pyramids of the jaws with a small foramen arched over; teeth keeled.

Spines small, short, slender; pedicellariæ very numerous.

*Recent.* Japan, Philippines, Samoa, Celebes, New Guinea, Sandwich Islands.

Genus *MICROCYPHUS*, *Agassiz*, 1841, *Monogr. d'Éch. viv. et foss.*, *Preface to Valentin, Anat. Gen. Ech.* p. 8. *A. Agassiz*, 1872-74, *Revision*, p. 466. *J. Bell*, 1880, *Proc. Zool. Soc.* p. 422. *Duncan*, 1888, *Ann. & Mag. Nat. Hist.* ser. 6, vol. i. p. 113, pl. xi.

Test moderate in size, thick, tumid, prolately spheroidal, or depressed, circular or somewhat pentangular in ambital outline, contracted actinally. Coronal plates few and very high in the interradia.

Apical system small; basal plates broad; madreporite well defined; all radial plates small, excluded, ornamented; periproct small; genital foramina deeply cut.

Ambulacra rather broad, sunken or not in the median line and along the poriferous zone; with numerous rows of small, equal, plain, low primary tubercles, and small secondary tubercles, all more or less absent along the median line and along the edges of the plates near their upper and lower transverse sutures, but crowded on the plates elsewhere. Sutures grooved, and with pits at the angles, especially in the median lines. Pairs of pores in triplets, made biserial by the adoral pair being near the tubercular part of the plates, the other pairs forming a vertical row near the interradial suture. Plates compound, the adoral component a large primary, the middle a demi-plate, and the aboral a low primary plate. Some tubercles in the poriferous zone.

Interradia with few and very high coronal plates, with tubercles resembling those of the ambulacra, crowding the surface in horizontal rows except near the median and the transverse sutures, which are more or less bare; the bare spaces and also the masses of tubercles being triangular in outline. Median line sunken or not. Sutures slight, yet broadly depressed; pits at the angles of sutures minute.

Peristome variable, decagonal or nearly circular; branchial incisions small; ten buccal plates. Perignathic ridges well developed; processes large, tall, united over a large foramen.

Spines short and slender, shortest and tapering abactinally.

Dowelling of the plates distinct, near the free surface, and in lines passing into the test. Blocking out of some ambulacral plates occurs during growth.

*Recent.* Japan, East-Indian Islands, Philippines, Navigators, Tasmania.

Genus AMBLYPNEUSTES, *Agassiz*, 1841, *Monogr. Éch. viv. et foss.*, *Valentin, Anat. Gen. Ech., Preface*, p. 9. *Desor*, 1858, *Synopsis*, p. 110. *A. Agassiz*, 1874, *Revision*, p. 478. *J. Bell*, 1880, *Proc. Zool. Soc.* p. 435, pl. xli. figs. 4-6. *Duncan*, 1883, *Journ. Linn. Soc.* vol. xvi. p. 354; and 1888, *Ann. & Mag. Nat. Hist.* ser. 6, vol. i. pl. xi. fig. 13, p. 116.

Test thin, moderate in size; circular or slightly pentagonal in tumid ambital outline, globular or prolate spheroidal. Coronal plates numerous.



Apical system small, slightly projecting; basal plates united; the genital pores at the adoral angle large or small according to sex; radial plates excluded, the pore visible from above; madreporite defined, openings circular; periproct with a crowd of small plates each with a miliary. Coronal plates numerous, low, broad.

Ambulacra broad, with rows of very small plain, faintly crenulate tubercles placed so as to leave a more or less definite median space, where there are pedicellariæ but no primary tubercles. Poriferous zones wide, with or without miliaries and secondaries; pores in oblique triple pairs, close vertically, the innermost pair is the adoral of a triplet. Plates numerous, compound; consisting, when large, of a large adoral primary plate, a small middle demi-plate, and a larger aboral demi-plate, which sometimes, especially abactinally in the test, becomes a primary plate.

Interradia with low broad plates; tubercles resembling those of the ambulacra, varying in vertical number and obliquity; a greater or less bare median space.

Sutures of both areas visible, narrow; minute shallow pits at the median angles, and sometimes along the median sutures; ornamentation plain, or of vertical zigzags of broad lines or of curved lines crossing the median area. Dowelling abundant.

Peristome variable in size, usually small; branchial incisions small. Perignathic ridges low, processes slender, high; foramen triangular or broad. Spines slender, short, striated, distant.

*Recent.* Australian and New Zealand seas, Fiji. (Cape of Good Hope?)

*Amblypneustes griseus* is a very erratic species; and it is evident that A. Agassiz is correct in relegating *A. pentagonus* to a separate genus.

Genus GONTIOPNEUSTES, gen. nov.

Test thin, nearly globular, but pentagonal in circumferential outline, the ambulacra projecting beyond the concave interradia. Coronal plates high and few.

Apical system delicate, with the madreporite in a large basal plate; other basals pointed, narrow, pentagonal; some radial plates enter the ring.

Ambulacra with two vertical rows of plain primary tubercles, with raised scrobicules; median spaces more or less bare; poriferous zones narrow; pairs of pores in triplets.

Interradia with tubercles resembling those of the ambulacra.

Peristome small. Spines of primary tubercles of great size.

*Recent.* Mauritius.

The above diagnosis is abstracted from the description of the solitary specimen of *Amblypneustes pentagonus*, A. Agassiz (Revision, p. 482).

Genus HOLOPNEUSTES, Agassiz, 1841, *Éch. viv. et foss.*, Valentin, *Anat. Gen. Ech.*, Preface, p. 9. A. Agassiz, 1872-74, *Revision*, p. 483. Bell, 1880, *Proc. Zool. Soc.* p. 439. Duncan, 1888, *Ann. & Mag. Nat. Hist.* ser. 6, vol. i. pl. xi. figs. 14-16, p. 117.

Test moderately stout or thin, globular or prolately spheroidal, or subconical above the tumid circular ambitus. Interradial coronal plates numerous; ambulacral plates very numerous.

Apical system projecting, stout; basal plates broad, subequal; radial plates excluded, the pore visible from above.

Ambulacra broader than the interradia; and the poriferous zone usually broader than the interporiferous area, slightly depressed, with secondary tubercles and granules; pairs of pores close vertically, irregularly distant horizontally, triserial or polyserial; an inner and an outer regular vertical series of pairs, and a confused middle series. The middle series of pairs of pores are in the aboral components of as many compound plates; the pairs of the outer vertical row are those of middle component plates, and the inner series of pairs are placed in adoral primary components which are often excluded from the ambulacro-interradial suture.

Tubercles of the interporiferous areas small, plain, variable in number, more or less median space exposed. Interradia with transverse rows of primaries and secondary plain tubercles; median area variable.

Sutures sunken, linear; pits at the angles small, but distinct, shallow; plates dowelled.

Peristome small, pentagonal, with small but distinct branchial incisions. Spines short, striated, may be swollen at the free end.

*Recent.* Australian seas.

The next genus links the Temnopleuridæ and the Echinidæ, but it is placed as *incertæ sedis*.

Genus GRAMMECHINUS, *Duncan & Sladen*, 1885, *Pal. Ind.* ser. xiv., *Monogr. Tert. Echin. Kachh & Kattywar*, p. 82, pl. xiii. figs. 7, 8.

Test moderately large, thin, rather depressed, swollen at the circular ambitus, conical above, flat and incurved actinally.

Apical system ?

Ambulacra with pairs of pores in triplets, from apex to peristome; plates low, narrow, composed as in the Echinidæ; tubercles small, the vertical series nearest the pores the largest, in one or three rows, plain. Interradial plates long and low, not twice the height of an ambulacral plate, carrying from one to eight primaries, in vertical rows, the middle row the largest, all slightly larger than those of the ambulacra, imperforate and non-crenulate; secondary tubercles in lines above and below the primaries and close to the horizontal sutures, forming ridges, with the line of the suture depressed between those of consecutive plates. Vertical narrow ridges extending dorsally and actinally from each of the large middle vertical series of tubercles to the transverse edges of their plates.

Peristome large, rather pentagonal; ambulacral margins only moderately wide and plain; branchial incisions distinct, with a raised border.

*Fossil.* Miocene: Asia (Kattywar).

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#### IV.

The Family Echinometridæ and its Subfamilies and Genera.  
The Family Echinidæ and its Genera.

VIII. Family ECHINOMETRIDÆ, *Gray*, 1855, *amended by A. Agassiz*, 1872, *Revision*, p. 423.

Regular ectobranchiate gnathostomes, with heteropodous or sub-heteropodous tentacles; test with the long axis not coinciding with the antero-posterior, and the compound ambulacral plates with three or more pairs of pores; or the test symmetrical and polyporous. Pyramids of jaws with epiphyses; teeth keeled.

Subfamily *Echinometrinæ* (p. 116).

Large tests, the long axis transverse to or forming small angles with the antero-posterior. Ambulacral plates with from three to nine components, each with a pair of pores.

Genus *Heterocentrotus*.  
*Colobocentrotus*.  
*Echinometra*.  
*Stomopneustes*.  
*Parasalenia*.

Subfamily *Polyporinæ* (p. 121).

Echinometridæ with symmetrical tests and having numerous pairs of pores.

Genus *Strongylocentrotus*.  
*Sphærechinus*.  
*Echinostrephus*.  
*Pseudoboletia*.  
*Eurypneustes*.  
*Æolopneustes*.

Subfamily *Echinometrinæ*.

Genus HETEROCENTROTUS, *Brandt* (subgenus), 1834-35, *Prodr. Desc. Anim.* p. 265; *Rec. d. Actes de l'Acad. St. Pétersb. (Additions)*, 1834-35. *A. Agassiz*, 1873, *Revision*, p. 427. *Lovén*, 1874, *Études*, p. 26. *J. Bell*, 1881, *Proc. Zool. Soc.* p. 420. *De Loriol*, 1883, *Éch. de l'Île Maurice*, p. 35. *Lovén*, 1887, *Ech. descr. by Linnæus*, p. 150.

Syn. *Cidaris* (pars), *Klein*; *Echinus* (pars), *Linnæus*; *Acrocladia*, *A. Agassiz*, 1846.

Test large, thick, elliptical in marginal outline, subhemispherical above, convex actinally, and concave from side to side there; elongate transversely, the antero-posterior axis being shorter than the transverse, which passes through ambulacra II. and IV.

Apical system raised; periproct small, slightly elliptical; the right anterior basal plate with a large madreporite; all basals tuberculate; radial plates excluded, tumid, perforated near the adoral edge; periproctal plates stout, spined; anal plates small. The genital pores are sometimes in the interradia.

Ambulacra broad, straight, wide at the peristome; interporiferous area narrow at the peristome, broad at the ambitus, and diminishing greatly in breadth abactinally; large plain tubercles actinally and at the ambitus, replaced abactinally by irregularly placed rows of secondary tubercles. Poriferous zone wide actinally, nearly touching at the median line abactinally, more or less broken up by tubercles. Plates compound, high, with as many

as nine components each perforated by a pair of pores; the aboral plate a small primary, the adoral a large primary, all the others demi-plates; pairs of pores polyserial actinally.

Interradia with few coronal plates, very narrow actinally, each plate with a large plain tubercle resembling the ambulacral, diminishing in size from the ambitus; secondary tubercles abundant.

Peristome large; branchial incisions broad; perignathic girdle well developed. Jaws with a tall narrow foramen; teeth keeled. Buccal plates large, spined, and with pedicellariæ. Spines very large, stout, long, flat, oar-shaped, or triangular in transverse section; secondary spines short, either forming a pavement around the primaries with their inflated ends, or sharp and pointed in the same position.

*Recent.* Red Sea to Sandwich Islands, Fiji, Mauritius, Java, New Caledonia, Australia. Of late years one species, *H. mamillatus*, has made its way from the Red Sea, *viâ* the Suez Canal, into the Mediterranean.

Genus COLOBOCENTROTUS, *Brandt* (subgenus), 1834, *Prodr. Desc. Anim.* p. 266; *Rec. d. l'Actes de l'Acad. St. Pétersb. (Additions)*, 1834-35. *A. Agassiz*, 1872-74, *Revision*, p. 423. *Lovén*, *Études*, 1874, p. 26; 1887, *Ech. descr. by Linnæus*, p. 158. *J. Bell*, 1881, *Proc. Zool. Soc.* p. 421.

Syn. *Echinus* (pars), Linnæus; *Cidaris* (pars), Leske; *Echinometra*, Gray, 1825; *Podophora*, Agass.

Test thick, moderate in size, elliptical or subcircular in rather tumid marginal outline, subconical, tumid, or depressed hemispherical abactinally; more or less concave, with a comparatively flat surface actinally; elongate transversely; the antero-posterior axis is shorter than the transverse, which passes through amb. II. and IV.

Apical system central; periproct small, with small plates; basal plates large, with primary and secondary tubercles upon them; radial plates excluded, small, with a tubercle, and the pore large and adoral.

Ambulacra straight, very broad actinally; plates high, composed of a small aboral primary, a large adoral primary, and from three to many intermediate small demi-plates; poriferous zones wide, and containing arcs of many pairs of pores separated and

confused by the presence of tubercles; polyserial at the actinal surface, and forming broad areas there. Primary tubercles as elsewhere, plain, in vertical rows, smallest in the poriferous zone and largest at the margin, becoming minute and close actinally. Tentacles heteropodous.

Interradia broad, but very narrow actinally, with several vertical rows of primary tubercles, largest at the margin, and very small and close actinally.

Peristome polygonal, broad anteriorly, with decided branchial incisions. Perignathic girdle well developed; ridges long and low; processes tall, slender, with a top piece, foramen large. Jaws large, with a very long foramen; teeth keeled. Peristomial membrane plain, but with ten small, spined buccal plates. Spines abactinally forming a pavement-like surface, short, hexagonal or globose at the end, some larger, longer, flat-ended, and projecting slightly at the ambitus; actinally short, and either stout or slender, cylindrical and pointed. Intermediate cylindrical and small spines may or may not exist between the abactinal series.

*Recent.* Zanzibar, Java, Sandwich Islands, Australia.

Genus ECHINOMETRA, Rondelet, 1554, *De Pisc. Marin.* p. 578.

Lütken, 1863, *Vidensk. Med. f. Nat. For. i Kjöbenh.*, pub.

1864, p. 86. A. Agassiz, 1872-74, *Revision*, pp. 282, 431.

Lovén, 1872, *Études*, p. 26; 1887, *Ech. descr. by Linnæus*, p. 153.

Syn. *Echinus* (pars), Linnæus, 1758; *Cidaris* (pars), Leske, 1778; *Heliocidaris* (pars), Agass., 1847.

Test moderate in size, stout, elongate elliptical in marginal outline, tumid dorsally; tumid between the margin and the large peristome, the whole actinal surface concave; unsymmetrical; the longer axis, which passes through amb. I. and interradium 3, does not coincide with the antero-posterior or transverse diameter of the test and is oblique.

Apical system central; basal plates tuberculate, the madreporite in the right anterior plate; radial plates small; periproct elliptical, its plates small, numerous. Coronal plates numerous.

Ambulacra straight; poriferous zones moderately broad, the 5 to 9 pairs of pores being in bold arcs; plates high, and composed of a large adoral and small aboral primary and all the others intermediate demi-plates. Tentacles heteropodous.

Tubercles plain, and smaller and less numerous than those of the interradia.

Interradia broad at the ambitus, narrow at the peristome, with several vertical rows of large plain primary tubercles.

Peristome large, pentagonal; branchial incisions broad. Perignathic girdle well developed; processes tall, with a large arch. Jaw-pyramids stout, with a large tall foramen and epiphyses; teeth keeled. Actinal membrane with spine-bearing buccal plates. Spines of primary tubercles moderately long, stout, faintly longitudinally striated, semi-solid, becoming suddenly slender and sharp, with a milled ring.

*Recent.* Pacific coast of Central America north to California and south to Peru; Zanzibar, Red Sea, Mauritius, Seychelles, Japan, Philippines, Sandwich Islands, Fiji, Senegal coast, Cape Verd, Bermudas, Caribbean Sea, Gulf of Mexico.

Genus STOMOPNEUSTES, *Agassiz*, 1841, *Monogr. Éch. viv. et foss.* livr. 1, *Pref.* p. x. *A. Agassiz*, 1873, *Revision*, p. 436. *Martin*, 1880, *Rev. Foss. Ech. Java (Notes Leyd. Mus.)*. *Stewart*, 1880, *Journ. Roy. Micr. Soc.* vol. iii. p. 911. *J. Bell*, 1881, *Proc. Zool. Soc.* p. 445. *De Loriol*, 1883, *Éch. de l'Île Maurice*, p. 32.

Syn. *Heliocidaris*, *Desm.* 1846.

Test moderate in size to very large, stout, circular or elliptical in the tumid marginal outline, swollen dorsally, but depressed; actinal surface flat. The antero-posterior axis of the test is oblique and forms a greater or less angle with the long diameter.

Apical system with a large madreporite; basal plates forming a narrow ring, with a secondary tubercle on each plate. Periproct large, with numerous plates with small tubercles.

Ambulacra straight, broad at the ambitus and at the peristome; poriferous zones narrow abactinally and wide actually; the pores in arcs of three pairs dorsally, and crowded and triserial below the ambitus, and interfered with nearly throughout by small secondary tubercles or granules. Interporiferous areas with two vertical rows of large, imperforate, plain, primary tubercles, and several rows of secondary tubercles and miliaries, some entering the poriferous zones, diminishing at the peristome, where the areas are narrow. Spicules of the tentacles very large.

Interradia with a linear groove in the median line, broad above the ambitus, narrow at the peristome, with two principal vertical rows of primary tubercles resembling those of the ambulacra in structure, but larger, diminishing, however, in size actinally and dorsally. There are also two rows of smaller primaries, smallest actinally, which reach some distance above the ambitus, with small secondary tubercles and granules irregularly distributed.

Peristome small, pentagonal, with moderately large branchial incisions.

Spines various, but moderate in length, stout, tapering, sharp, solid, finely striated longitudinally; a prominent milled ring. Ophiocephalous pedicellariæ abundant, large, their jaw-processes much dentate; gemmiform pedicellariæ probably absent; tridactyle pedicellariæ abundant.

*Fossil.* Tertiary: Java?

*Recent.* Mauritius, Java, Samoa.

GENUS PARASALENIA, *A. Agassiz*, 1863, *Bull. Mus. Comp. Zoöl.* vol. i. p. 22; 1873, *Revision*, p. 435. *Stewart*, 1880, *Journ. Royal Micr. Soc.* vol. iii. p. 910.

Test moderate in size, stout, elliptical, tumid, unsymmetrical, the long axis passes through ambulacrum I. and interradium 3, and is oblique to the antero-posterior axis.

Apical system large, prominent. Basal plates large. Periproct small, with four triangular plates; anus at their inner points.

Ambulacra with two vertical rows of plain primary tubercles, not reaching the apical system; pairs of pores in arcs of three pairs.

Interradia with a small number of coronal plates, carrying two vertical rows of plain primary tubercles resembling those of the ambulacra.

Peristome large; branchial incisions slightly raised; buccal plates with spinules. Jaws with a high foramen; teeth keeled. Spines stout, cylindrical, pointed, moderately long.

Pedicellariæ few, the gemmiform without a secondary solid fang. Tridactyle pedicellariæ delicate.

*Recent.* Zanzibar, Kingsmill Islands, Bonin Islands.



Subfamily *Polyporinæ* (p. 116).

GENUS STRONGYLOCENTROTUS, *Brandt*, 1834, *Prodr. Descr. Anim., Rec. des Actes de l'Acad. St. Pétersb. (Additions)*, p. 265. *Lovén, Études*, 1874, p. 21 (as *Toxopneustes*). *A. Agassiz*, 1872-73, *Revision*, pp. 276 & 438.

Syn. *Loxechinus*, *Desor*, 1858; *Toxopneustes*, *Agassiz*, 1841 (pars); *Heterocidaris*, *Desm.*, 1846 (pars); *Toxocidaris*, *A. Agassiz*, 1863; *Anthocidaris*, *Lütke*, 1864; *Eurechinus*, *Verr.*, 1866.

Test moderate and large in size, broader than high, circular or subpentagonal in tumid ambital outline, swollen, subconical, depressed dorsally, slightly tumid around the actinostome. Coronal plates numerous.

Apical system large; madreporite large, in the usual basal plate, which is the largest; other basal plates unequal in size, all with some small secondary tubercles; radial plates broad adorally, some entering the periproctal ring. Periproct subcircular, with numerous crowded, minutely tuberculate plates.

Ambulacra straight, broad at the ambitus and peristome; poriferous zones broad; pairs of pores in oblique arcs, or almost in transverse, slightly bent series of from four to eight or ten pairs, polyserial and crowded actinally. Plates high, compound; the adoral component a large primary plate with its pair of pores the remotest from the interradius; the aboral plate a small primary with an oblique adoral suture, its pair of pores not quite so remote from the interradius as the adoral pair; other plates demi-plates, with their pairs of pores gradually diminishing in distance from the interradius, from above actinally. Interporiferous area with two vertical rows of imperforate plain non-scribulate primary tubercles, wide apart at the ambitus, narrowed and close and small actinally; vertical rows of secondaries and miliaries between and at the sides, some intruding upon the poriferous zones and separating the arcs more or less.

Interradia with high ambital and low actinal plates; two vertical rows of primary tubercles similar in structure to, but larger than, those of the ambulacra, and four or more vertical rows of secondary tubercles; granules somewhat regularly placed; areas much narrower actinally than those of the ambulacra.

Peristome small, sunken, polygonal; branchial incisions well developed, with everted edges.

Perignathic girdle with high ridges and high oblique processes forming a tall arch. Jaws tall; foramen large, tall, closed above; teeth keeled. Buccal membrane with ten plates with tentacles and pedicellariæ. Spines short, sharp, cylindrical, tapering, longitudinally striated.

*Fossil.* Late Tertiary and (?) Miocene: Europe and America, Java.

*Recent.* European seas, world-wide; shallow, to 45 fathoms or more.

Genus SPHÆRECHINUS, *Desor*, 1858, *Synopsis*, p. 134. *A. Agassiz*, 1873, *Revision*, p. 451. *Hamann*, 1886, *Sonder-Abdr. aus d. Sitzungsab. d. Jenaisch. Ges. für Med. und Naturw.*

Test moderate or large, globular, spheroidal, or depressed, flat actinally. Coronal plates numerous, low and broad.

Apical system prominent; periproct large, plated; basal plates forming with all or some of the radial plates a rather narrow ring, carrying secondary tubercles and miliaries, those on the plate with the madreporite most numerous.

Ambulacra straight, wide; pairs of pores in arcs or oblique lines of from four to eight pairs, with small tubercles or granules interposing or separating the series; pairs polyserial actinally; interporiferous areas with two to six vertical rows of plain imperforate primary tubercles, slightly smaller than or equal to those of the interradia.

Interradia broad, with from two to twelve vertical rows of primaries plain and imperforate, large, with horizontal rows of secondary tubercles and miliaries.

Peristome small, decagonal, with deep, long branchial incisions; buccal membrane with plates, in relation with the ambulacra, and carrying pedicellariæ and large tentacles. Perignathic girdle slender, with low stout ridges and slender processes and a large arch. Spines stout, short, crowded. "Globifera" pedicellariæ present and large.

*Fossil.* Pliocene: Europe.

*Recent.* Mediterranean, Canaries, Australia, Mauritius, New Zealand, Japan, and the China seas.

Genus ECHINOSTREPHUS, *A. Agassiz*, 1863, *Bull. Mus. Comp. Zool.* vol. i. p. 20; 1873, *Revision*, p. 457. *Stewart*, 1880, *Journ. Roy. Micr. Soc.* vol. iii. p. 909. *De Loriol*, 1883, *Éch. de l'Île Maurice*, p. 31.

Test moderate in size, circular or pentagonal in tumid ambital outline, turban-shaped, but depressed above and widest there, flat below. Plates rather numerous, high actinally, low and broad dorsally.

Apical system circular, large; the ring narrow; basal plates equal and large; the radial plates small and wedged in between the basals, but excluded; periproct polygonal, and with large and small plates.

Ambulacra with rather broad poriferous zones; pores in arcs of three or four pairs; interporiferous area with two rows of vertically placed, imperforate and plain, primary tubercles flanked by a vertical row of smaller tubercles placed near the poriferous zone; median area with secondary tubercles and miliaries, arranged more or less around the primary tubercles.

Interradia broad, with six to ten vertical rows of uniform, imperforate, plain primary tubercles resembling those of the ambulacra, diminishing in size and number away from the ambitus; miliaries and secondary tubercles scattered actinally, arranged around the primaries dorsally.

Peristome circular, with small branchial incisions; buccal membrane with plates in continuation with the ambulacra, carrying pedicellariæ and tentacles; the rest bare.

Perignathic girdle with low ridges and well-developed processes.

Spines moderate, tapering, cylindrical, stout, sharp, longest dorsally.

*Recent.* Pacific Ocean, Society Islands, Zanzibar, Natal.

Genus PSEUDOBOLETIA, *Troschel*, 1869, *Verhandl. d. Naturhist. Ver. preuss. Rheinl. u. Westfalens*, ser 3, vol. vi. p. 96, pl. 26. *A. Agassiz*, 1873, *Revision*, p. 454. *J. Bell*, 1881, *Proc. Zool. Soc.* p. 433. *De Loriol*, 1883, *Ech. de l'Île Maurice*, p. 28.

Test moderate and large, circular in tumid ambital outline, much broader than high, subconical, depressed dorsally, and flat actinally. Coronal plates numerous, low and broad.

Apical system small, with the basal plates unequal in size, madreporite in the largest; two postero-lateral radial plates

separate basals and enter the ring. Periproct small; plates uniform in size except close to the anus, where they are small, tuberculated.

Ambulacra straight, broad, with four to six rows of primary tubercles, plain and imperforate, with circles of granules around them, scarcely smaller than those of the interradia, all but the external series disappearing towards the apex; poriferous zones broad, with small tubercles between the pairs. Pairs of pores in arcs of four pairs or triserial; the inner row consists of adoral pairs in the adoral primary plates of the compound plates; the outer vertical row consists of series of two pairs closely superimposed, and separated by a tubercle, they are in middle demi-plates; the middle vertical row has its pairs separated by a tubercle, and they are in the aboral demi-plates.

Interradia with many, from 9-14, vertical rows of primary tubercles, similar in structure to those of the ambulacra, diminishing to two vertical rows abactinally; an irregular median area without tubercles; scrobicular circles large; miliaries parallel to the horizontal sutures, and vertically between the tubercles; secondary tubercles scattered irregularly.

Peristome large, flush, decagonal, with broad and deep branchial incisions. The buccal membrane with ten large plates with spines, pedicellariæ, and tentacles, also other spiniferous small plates. Spines short, sharp, finely striated.

*Recent.* Sandwich Islands, Philippines, Mauritius; shallow water.

Genus EURYPNEUSTES, *Duncan & Sladen*, 1882, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, pt. ii. p. 45.

Test large, subconical, depressed.

Ambulacral areas very broad, only rather narrower than the interradia. Poriferous zones broad, and the pairs of pores triserial. Plates very low and numerous, composed of five or six component plates, very close vertically, the adoral plate a very low primary, its pair of pores being near the interporiferous area; the other plates demi-plates, or sometimes the aboral component is a primary; the successive pairs have a tendency to be close to the one immediately above, and then to be distant, but the inner and outer rows are fairly persistent, and the middle variable in position. Two vertical rows of small crenu-

late, imperforate tubercles in each interporiferous area near the poriferous zones; small tubercles or granules near them amongst the pairs of pores.

Interradia with two or more vertical rows of small crenulate tubercles diminishing in number actinally. Miliaries numerous.

*Fossil.* Eocene: W. Sind, Asia.

Genus *ÆOLOPNEUSTES*, *Duncan and Sladen*, 1882, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, pt. ii. p. 47.

Test large, tumid, subcircular or subpentagonal in outline, subconical depressed abactinally, flat actinally, with a slightly depressed peristome. Twice as broad as high.

Apical system wanting.

Ambulacra broad, more than half of the breadth of the interradia at the ambitus, slightly prominent in contradistinction to the interradia, which are sunken along their median lines. Poriferous zone broad dorsally, narrow at the peristome; abactinally the pores are in almost horizontal arcs of five or six pairs, and are very regularly and closely placed; below the ambitus the number of pairs in each arc diminishes, the arcs straighten vertically, and the series of pairs become less oblique and almost uniserial, and are quite close to the peristome. The ambulacral plates are nearly as high as the corresponding interradiial plates and are compound; the composition of a plate halfway between the peristome and the ambitus is a low broad adoral primary plate, followed aborally by a large primary which is low near the ambulacro-interradiial suture and expanded elsewhere, and comprises all the median sutural edge of the compound plate except that adoral portion which belongs to the small adoral primary component; above the large primary is a small demi-plate, and the aboral plate of the combination is also a demi-plate, but is larger than the other, and has its adoral suture convex towards the primary tubercle of the compound plate. In some compound plates the low adoral primary is replaced by a small low demi-plate, with its aboral suture convex towards the primary tubercle; and in these instances the composition of the plate is mainly that of *Diadema*. Close to the peristome the adoral and aboral plates are low primaries. The pairs of pores are close and round. Interporiferous areas with a vertical row of small crenulate primary tubercles raised above the test and large and small granules.

The interradia have numerous low broad plates, somewhat wavy in sutural outline, depressed near the median line; two vertical rows of primary tubercles resembling those of the ambulacra, but slightly larger, and two other rows of smaller tubercles which diminish in number remote from the ambitus; numerous distant large granules.

Peristome small, sunken; branchial incisions with rounded edges and rather large.

*Fossil.* Eocene: W. Sind, Asia.

### IX. Family ECHINIDÆ.

Regular ectobranchiate gnathostomes, having tests with equal diameters, and with homoiopodous tentacles. Ambulacral plates compound, with three pairs of pores, which are arranged in high or low arcs of triplets. Coronal plates without pits and grooves, and their opposed surfaces plain. Jaws with epiphyses teeth keeled.

Genus *Echinus*.

Subgenus *Psammechinus*.

Genus *Stirechinus*.

*Glyptechinus*.

*Leiopedina*.

*Hypechinus*.

*Toxopneustes*.

*Boletia*.

Genus *Tripneustes*.

Subgenus *Evechinus*.

Incertæ sedis: *Prionechinus*.

Genus ECHINUS, Rondelet, *De Pisc. Marin.* 1554. Lister, 1678, *Anim. Ang.* p. 169, pl. 3. fig. 18. Linnæus, 1752-64, *Mus. Lud.-Ulr.* (pars). Agassiz, 1841, *Monogr. d'Éch. viv. et foss.*, *Pref. to Valentin, Anat. Gen. Echin.* p. 2. Desor, 1858, *Synopsis*, p. 123. A. Agassiz, 1872-4, *Revision*, pp. 293 & 489. Lovén, 1887, *Ech. descr. by Linn.* pp. 49 & 61.

Test varying in size, small, moderate, to very large, tumid at the circular or subpentagonal ambitus, subhemispherical, subconical, or tumid dorsally, flat or slightly tumid actinally, tall and short.

Apical system either compact, or some radial plates separating some basal plates; madreporite in the largest basal. The oval or circular periproct with numerous plates, smallest near the anus.

Ambulacra narrow to moderately wide, straight; poriferous zones narrow, pairs in more or less vertical arcs of triplets, the innermost pair the adoral of the three, and in a primary constituent; the other pairs in demi-plates, or the upper member may be a low primary. Interporiferous areas with two rows of small, plain, primary tubercles, placed vertically, with or without irregularly placed secondary tubercles and primaries.

Interradia with two vertical rows of tubercles resembling those of the ambulacra, or slightly larger, with few or numerous rows of secondary tubercles and miliaries, or a considerable number of small tubercles diminishing in number abactinally; tubercles most numerous below the ambitus.

Peristome rather small, nearly circular; branchial incisions not large; perignathic girdle well developed, processes tall and arched. Jaws high; foramen of the pyramid high and arched by epiphyses; teeth keeled. Buccal membrane with ten buccal plates with tentacles and small spines; some may have numerous buccal plates with a corrugated aspect. Tentacles homoiopodous, disciferous. Spines either very short relatively or moderately long, striated, sharp, more or less swollen at the base.

*Fossil.* Cretaceous to Pliocene and Post-Pliocene: Europe. Pliocene: England. Tertiary: Asia.

*Recent.* World-wide, littoral to 2435 fathoms.

The genus *Psammechinus*, Agass., 1846, Catal. Rais., Ann. d. Sci. Nat. vol. vi., and Desor, 1858, Synopsis, p. 118, really differs from the typical *Echini* in having the buccal membrane with concentric plates besides the ten buccal plates; but palæontologists have usually termed those species of *Echinus* which have numerous subequal tubercles *Psammechinus*. The size of the branchial incisions does not afford a generic distinction. Desor was not warranted in comparing the buccal and other plates with those of *Cidaris*. It is certain that some *Echini* with few tubercles, as well as others with many, have the peristomial membrane with numerous plates; and thus the distinction relied upon fails. At the most *Psammechinus* is a subgenus of *Echinus*; and the sole structural character refers to the peri-

stomial membrane with its numerous plates. Practically the subgenus is of no great value\*.

Genus STIRECHINUS, *Desor*, 1858, *Synopsis*, p. 131.

Test tall, circular at the tumid ambitus, subconical dorsally, flat actinally.

Apical system ?

Ambulacra moderately broad, with high compound plates ; the pairs of pores in arcs of triplets, the adoral plate of the compound a large primary, the median plate a demi-plate, and the aboral a low oblique primary plate. Two vertical rows of imperforate, plain, primary tubercles, large, and each situated upon a rising of the plate, so as to give a keeled appearance to the ambulacrum beneath the bases of the tubercles.

Interradia with two vertical rows of tubercles resembling those of the ambulacra, and situated on raised keel-like projections. Sutures distinct. Variable rows of secondary tubercles and miliaries.

*Fossil*. Pliocene : Europe.

Genus GLYPTECHINUS, *De Loriol*, 1873, *Éch. Crét. de la Suisse, Pal. Suisse, les Oursins*, pt. ii. p. 169, pl. xi.

Test small, circular in outline, tall, subconical or subhemispherical dorsally, flat actinally.

Apical system wanting.

Ambulacra straight, moderately broad ; the poriferous zones with the pairs of pores in arcs or triple oblique series ; the plates compound, as in *Echinus* ; the interporiferous areas with two vertical rows of plain tubercles, placed near the poriferous zones ; some secondaries at the ambitus, and granular throughout.

Interradia depressed along the median sutures, with two vertical rows of plain tubercles resembling those of the ambulacra ; each row is on a raised vertical keel, situated in the middle of the plates ; several rows of secondary tubercles. The transverse sutures of the interradial coronal plates, which are moderately numerous, grooved decidedly.

*Fossil*. Cretaceous : Europe.

The alliance of this genus is with the Tertiary *Stirechinus*.

\* On p. 91 it was noticed that *Microopsis Vidali*, Cott., was a *Psammechinus* with crenulate and perforate primary tubercles. This carries the subgenus back in time considerably.



Genus *LEIOPEDINA*, *Cotteau*, 1866, *Rev. et Mag. de Zool.* sér. 2, vol. xviii. p. 206. (*Amended.*)

Syn. *Chrysomelon*, *Laube*, 1869, *Ech. Vincent. Tert.*, *Denks. d. k. Akad. Wiss. Wien*, 2 Abth. p. 13.

Test large, swollen, prolate spheroidal or globular, subconical dorsally, broadest beneath the equator, and subpentagonal or circular in marginal outline.

Apical system central, small, flush.

Ambulacra long, straight, very broad; poriferous zones broad, with vertically close, triserial pairs of pores almost horizontal; usually the pair nearest the interporiferous area the largest, the pores of it being elongate, those of the other pairs circular. Plates very numerous, low, broad, compound, composed of a large adoral primary plate, a median demi-plate, and a very low aboral primary plate. The adoral and aboral pairs of pores of a triplet remote from the interradium; the median pair in the demi-plate, close to it. Tubercles of the interporiferous areas small, distant, finely perforate, plain, subscrobiculate, in two, distant, vertical rows. Granules between the tubercles homogeneous.

Interradia broad, with two vertical rows of tubercles similar to those of the ambulacra, with intermediate granules, some of which may have mamelons near the apical system.

Peristome small, subcircular, flush; amount of branchial incision variable.

*Fossil.* Eocene: Europe.

Genus *HYPECHINUS*, *Desor*, 1858, *Synopsis*, p. 130, pl. xviii.

Test moderate in size, tumid at the circular ambitus, nearly hemispherical dorsally, but slightly depressed.

Ambulacra with wide poriferous zones; pairs of pores in oblique triple series; plates low, compound; the median pair of pores being in a demi-plate, and placed nearer the interradiial suture than the other pairs; the adoral pair very remote from the interradiial suture and in a primary plate. Interporiferous areas with two vertical rows of small, numerous, plain primary tubercles, which are much larger actually than above the ambitus.

Interradia with numerous coronal plates; the primary tubercles imperforate and plain, in two distant vertical rows; the tubercles

are larger than those of the ambulacra, and all are largest actinally.

*Fossil.* Middle or Upper Tertiary : Patagonia, S. America.

The genus *Toxopneustes*, Agassiz, 1841, is unsatisfactory ; and in order to clear away some differences of opinion regarding its value, it is necessary to revert to the diagnosis given in the Preface to livr. 4 of 'Monogr. d'Éch. viv. et foss.' p. ix :— "Le genre *Toxopneustes* a des ambulacres formés de séries arquées de doubles pores, convergeant vers le milieu des aires et séparées par des rangées parallèles de petites pores. Chaque série arquée se compose de six à neuf paires de pores. Vers la bouche il y en a moins ; mais elles sont plus rapprochées. Les tubercules des séries principales sont assez grands. L'ouverture inférieure du test offre dix échancrures peu profondes. Je prends pour type de ce genre l'*Echinus tuberculatus* ; j'en connai quelques espèces inédites."

The genus had been simply named in livr. 2, p. 7, of the same work during the same year ; and *Echinus pileolus*, Lmk., was then decided to be the type.

It is evident that Agassiz meant that the genus should include polypores ; and the word "pores," at the close of the first sentence of the definition given above, should be "tubercules." The genus thus covered the same ground as *Strongylocentrotus*, Brandt, 1835.

The reason why *Echinus pileolus* was not made the type, when the genus was finally diagnosed by Agassiz is tolerably evident ; for it is not a polypore, and is more closely allied to a *Tripneustes* than to *Echinus tuberculatus*.

On reference to A. Agassiz's 'Revision,' p. 167, the synonymy of the genus can be seen ; and it will be noticed that no less than six genera have been founded which cover the same ground. *Toxopneustes* did not reappear until the date of the 'Revision,' and four species of it are admitted by the distinguished author—*T. maculatus*, *T. pileolus*, *T. semituberculatus*, *T. variegatus*. But it is a matter of fact that not one of these species has the generic characters defined by the elder Agassiz in the 'Monographie.'

There is therefore no such genus as *Toxopneustes*, Agassiz ; he merely gave a name, and his diagnosis did not distinguish his two types. In the 'Revision' of A. Agassiz, p. 297, there is a generic definition of *Toxopneustes* which differs very materially

from that of his father, and which may stand for the generic attribute of three out of the four species admitted and just noticed. *T. pileolus* cannot well enter, as De Loriol has shown, (*Éch. de l'Île Maurice*, p. 27).

Genus TOXOPNEUSTES, A. Agassiz, 1872-4, *Revision*, p. 297. (*Limited*.)

Non Agassiz, 1841, *Préf. Monogr. d'Éch. viv. et foss.* livr. 4, p. ix, = *Strongylocentrotus*, Brandt, 1835.

Test moderate in size, circular or subpentagonal in tumid marginal outline, subconical, broader than high.

Apical system well developed, some radial plates entering the periproctal ring or not.

Ambulacra moderately broad; the pairs of pores forming broad arcs of three pairs, rather close vertically, and the pairs of the arc not far apart; the inner pairs of pores are adoral in the triple compound plates, which are like those of *Echinus*. Interporiferous areas with two principal vertical rows of plain imperforate primary tubercles moderate in size, with rows of secondaries with or without granules; most tubercles at and below the ambitus.

Interradia with several vertical rows of primary tubercles resembling those of the ambulacra, diminishing to two near the apex, granular or not. Bare median spaces variable or none.

Peristome large, usually but not invariably with deep incisions for the branchiæ. Jaws and teeth as in *Echinus*. Buccal plates and also concentric, wide, low plates in the membrane. Spines short, moderately stout.

*Recent*. From the coast of Brazil to Carolina inclusive, and the Caribbean Islands; Bermuda; Christmas Island; Bourbon; Galapagos; Central (Pacific) America.

*Toxopneustes pileolus*, A. Ag., = *Echinus pileolus*, Lmk., is a *Boletia*.

Genus BOLETIA, Desor, 1858, *Synopsis*, p. 133; 1847, *Catal. Rais.*, *Ann. d. Sci. Nat.* vol. vi. p. 58. Verrill, 1871, *Notes on Radiata*, p. 581. De Loriol, 1882, *Éch. de l'Île Maurice*, p. 27.

Syn. *Toxopneustes* (pars).

Test moderate and large, thick, subpentagonal at the tumid ambitus, subconical dorsally, concave actinally, broader than high; the ambulacra projecting somewhat.

Apical system large, madreporite large, and in the largest basal plate (No. 2); some radial plates enter the periproct.

Ambulacra broad, with numerous, low, compound plates; poriferous zones broad, the pairs numerous, close vertically, but moderately far apart in the slightly inclined arcs or straight and horizontal series of three pairs. The plates as in *Tripneustes*, but slightly higher and narrower. Small tubercles in the poriferous zones; interporiferous areas with several vertical rows of moderately large primary tubercles, diminishing in number above the ambitus.

Interradia with numerous rows of plain, primary tubercles resembling those of the ambulacra, diminishing in number apically. A more or less bare space on either side of the median ambulacral and interradial lines near the apical system.

Peristome large, with deep and long incisions for the branchiæ, the edges turned up. Pedicellariæ very large. Spines small, striated.

*Recent.* Mauritius, East Indian Islands, Pacific Islands, Panama.

The alliance to *Tripneustes* is close, the main distinctions being the shape and the concave actinal surface with its large well-cut peristome; the poriferous zones are also narrower in *Boletia* and a more arched arrangement of pairs occurs, remote from the ambitus, where the structure of the ambulacral plates is as in *Tripneustes*; there are no double plates, however, as in the fossil *Tripneustes*.

Genus TRIPNEUSTES, *Agassiz*, 1841, *Introd. to livr. 2, Monogr. d'Éch. viv. et foss.* p. 7; also 1841, *Monogr. d'Éch. viv. et foss.* livr. 4, *Preface to Val. Anat. d'Éch.* p. viii. *Desor*, 1858, *Synopsis*, p. 132. *Lütken*, 1863 (pub. 1864), *Vid. Medd. f. Nat. For. i. Kjöb.* p. 95. *A. Agassiz*, 1872-4, *Revision*, p. 301. *J. Bell*, 1879, *Proc. Zool. Soc.* p. 655. *De Loriol*, 1883, *Éch. de l'Île Maurice*, p. 25. *Duncan & Sladen*, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, pt. v. p. 310, pls. 48, 49.

Syn. *Hipponoe*, Gray, MSS. name, 1840; *Heliechinus*, Girard.

Test moderate to very large, thin, tumid, circular or sub-pentagonal in outline, broader than high, often subconical, tumid around the peristome; may be depressed and concave around a sunken apical system, with or without depressed inter-radial median areas abactinally.

Apical system large, madreporite large and in the usual basal plate; some radial plates entering and separating basals; periproct large, its plates numerous, small, tuberculate, and spine-bearing.

Ambulacra very wide, nearly equalling the interradia in breadth, and the widest at the peristome; poriferous zones very broad; the pairs of pores large, triserial, very close vertically and distant horizontally, the inner and the outer rows very persistent and vertical, the middle row somewhat variable in the direction of the pairs of pores; small primary tubercles amongst the series of pairs; the plates very low and numerous, broad, compound; the adoral constituent with the inner pair of pores is a primary plate which is low in the poriferous zone, and occupies all the interporiferous part of the compound plate; the next plate above is a demi-plate with the outer pair of pores, and the upper component is a broad demi-plate with the middle pair of pores. The compound plates may join and two produce a large one, and the primary plate of the upper component may be formed into a demi-plate. Interporiferous areas with several vertical rows of small primary tubercles plain and imperforate.

Interradia with very numerous coronal plates and many, somewhat distant, vertical rows of primary and secondary tubercles resembling those of the ambulacra. More or less bare median areas in the ambulacra, and especially in the interradia abactinally; the angles of the sutures slightly pitted.

Peristome comparatively small, with a tumid surface beyond, the branchial incisions large and long; perignathic girdle with low ridges, and very tall slender oblique processes, uniting largely above; arch large. Jaws high, with a large foramen, teeth keeled. Spines short, sharp, striated. Peristomial membrane with ten large plates and other small ones.

*Fossil.* Miocene: Europe?, W. Sind, Asia.

*Recent.* Gulf of Suez, Red Sea, E. coast of Africa, Mauritius, Rodriguez, Masbate, Philippines, Japan, East Indian Islands, Gulf of California, Caribbean Sea to Bermuda.

Subgenus *EVECHINUS*, *Verrill* (genus), 1871, *Notes on Radiata*, p. 583; 1871, *Trans. Connect. Acad.* vol. i. no. 8. *A. Agassiz*, 1872-74, *Revision*, p. 502.

Coronal plates moderate in number, the branchial incisions

slight. Few buccal plates. Tubercles rather large, with secondaries; bare median areas slight.

*Recent.* New Zealand.

*Genus incertæ sedis.*

The following diagnosis is taken from the description of the solitary species so well described by Agassiz in the Report on the 'Challenger' Echini:—

Genus PRIONECHINUS, *A. Agassiz*, 1879, *Proc. Amer. Acad.* vol. xiv. p. 202; 1881, *Report on 'Challenger' Echini*, p. 109, pls. vi. A. & xl.

Test thin, small, circular in the tumid marginal outline, depressed.

Apical system large and compact; basal plates broad, angular, and with secondary tubercles on their periproctal edge; radial plates large, projecting much beyond the basal plates, pore adoral.

Ambulacra narrow; the poriferous zones rather broad, with two pairs of pores to a plate, in simple vertical series.

Interradia with two vertical rows of large plain tubercles placed near the median suture and sparsely distributed granules and small tubercles. Interradia with the coronal plates only slightly higher than those of the ambulacra, a primary tubercle on each about the dimensions of an ambulacral primary, surrounded by some secondary tubercles. Pedicellariæ large-headed.

Spines prominently serrated and rather flat.

Peristome with slight branchial incisions; five pairs of large buccal plates, and only one large tentacle to a pair of plates.

*Recent.* Philippines and Australia, 700 to 1070 fathoms.

It is impossible to place this genus satisfactorily, so it must remain as *incertæ sedis*.

V.

Order III. The Holoctypoida, its Sections and Genera. Order IV. The Clypeastroida, remarks. Family Fibulariidae and Genera. Family Clypeastriidae and Genera. Family Laganidae and Genera. Family Scutellidae, Genera and Subgenera. Subfamily Arachninae, and Genus.

Order III. HOLECTYPOIDA (p. 25).

Syn. *Galeritidae* and *Echinoconidae*, auct. (pars).

This is the first Order of the Exocyclica, and it is a difficult one to classify, for there is much diversity of opinion regarding the nature of the perignathic girdles and jaws of some genera (see p. 22). Some genera have all the other characters of the Order, but research has not decided finally upon the presence or absence of jaws and teeth. In other genera the perignathic girdle is weak, and there are teeth; and in two genera the perignathic girdle forms a strong collar and the interradian portions or "ridges" are wide and bent upwards and outwards from the peristome internally.

The Order may be divided into two sections, and in both the apical system is compact, but the number of the perforate basal plates differs; the madreporite is in the right anterior basal plate, but it may extend back and separate the postero-lateral basal plates. The ambulacra are straight, flush, and apetaloid. The peristome is decagonal or circular, and has branchial incisions often well developed, or the reverse; the peristomial margin is composed of two plates in each ambulacrum, and double plates in each interradium, but the odd area may have a single plate. The periproct is variable in its position in the posterior interradium. Tentacles are restricted to ambulacral plates.

*Section I.*—The perignathic processes of the ambulacra present.

- Genus *Holoctypus*.
- Pileus*.
- Pygaster*.
- Pygastrides*.

*Section II.*—Perignathic girdle with well-developed interradian ridges; ambulacral "processes" rudimentary or absent.

- Genus *Discoidea*.
- Subgenus *Echinites*.
- Genus *Conocephalus*.

Genera incertæ sedis: *Galeropygus*, *Pachyctypus*.

## Section I.

Genus *HOLECTYPUS*, Desor, 1842, in Agassiz, *Monogr. d'Éch. viv. et foss.*, *Des Galérit.* livr. 3, pp. 52 & 63 (a group of Discoida). Desor, 1858, *Synopsis*, p. 168. Lovén, 1874, *Études*, pl. xiv. fig. 124. Cotteau, Péron et Gauthier, 1880, *Éch. foss. de l'Algér.* 6 fasc. pl. vi. fig. 7. De Loriol, 1888, *Faune Crét. du Portug.*, *Éch.* vol. ii. fasc. 2, p. 69 et seq.

Moderate-sized Urchins with a circular, or slightly pentagonal, tumid ambitus; subconical or depressed dorsally, tumid and more or less hollowed for the central peristome.

Apical system small, central, with five basal plates, the fifth being sometimes small and without a duct-pore; madreporite in basal No. 2, extending centrally and separating the postero-lateral basals.

Ambulacra narrow, straight, widest at the ambitus; pairs of pores in simple series; plates numerous, usually simple, small, low primaries, some plates compound, and a demi-plate often occurs aborally in some compound plates, which carry numerous small primary tubercles. Tubercles, small primaries in many vertical rows.

Interradia with rather large plates, many vertical rows of primaries, larger than those of the ambulacra.

Peristome central, large, decagonal, with well-marked branchial incisions. Pyramids of jaws slender, with a large foramen; teeth slender, grooved (?). Perignathic girdle feeble and not continuous. Periproct large, pyriform, in the posterior interradius between the peristome and the posterior edge of the test; its plates largest posteriorly, smallest near the minute anus anteriorly.

*Fossil.* Oolites: England, Europe, N. Africa; Cretaceous: Europe, N. Africa, Asia, N. America.

The increase of dimension of the madreporite and the presence of the perforation in the fifth basal are characteristic of the Cretaceous species.

Genus *PILEUS*, Desor, 1858, *Synopsis*, p. 167.

Large Urchins, pentagonal in marginal outline, tumid and sub-hemispherical abactinally, more or less flat actually.

Apical system central, very small, with five basal plates, the fifth imperforate, the madreporite in basal No. 2, and also separating the postero-lateral basals.



Ambulacra long, narrow, straight; primary tubercles very small, without definite order; pairs of pores in simple series abactinally, diplopodous towards the ambitus; plates low primaries, but possibly compound near the ambitus.

Peristome central, decagonal, deeply incised for the branchiæ. Perignathic girdle present (ambulacral processes).

Interradial ornamentation of many scattered rows of small tubercles. Periproct supra-marginal, small, broadly ovoid, opening flush.

*Fossil.* Oolite: Europe.

It is not a satisfactory genus.

Genus PYGASTER, *Agassiz*, 1839, *Éch. Foss. de la Suisse*, p. 79. *Desor*, 1842, in *Agass. Monogr. d'Éch. viv. et foss.* livr. 3, p. 75. *Desor*, 1858, *Synopsis*, p. 164. *Wright*, 1856, *Pal. Soc. Monogr., Ech. Ool. Form.* p. 273. *Étallon*, *Éch. Haut-Jura, Suppl.* p. 4, and *Lethæa Bruntrutana*, pl. xlv. *Cotteau & Triger*, 1859, *Éch. de la Sarthe*, p. 175, pl. xxx. fig. 16. *Lovén*, 1887 (pub. 1888), *Bih. till Kongl. Svenska Vet.-Akad. Handl.* Bd. 13, Afd. iv. no. 10, p. 8 et seq. pl. ii.

Test large, with a circular or pentagonal, rather sharp ambital outline; subconical and depressed dorsally, more or less truncate behind and concave actinally.

Apical system central or slightly excentric in front, small, with four perforated basal plates; the madreporite large, in basal No. 2, and extending backwards centrally, reaching the widely separated posterior radial plates and the anterior edge of the periproct.

Ambulacra straight, similar, flush or slightly raised, increasing in width to the ambitus and diminishing thence to the peristome; with straight narrow, simple poriferous zones; a pair of pores to a plate, but actinally there are some compound plates, and some fusion of them at the peristome. Tubercles of the interporiferous areas in two or four vertical rows, slightly smaller than those of the interradia, but otherwise similar.

Interradia very broad actinally, with low, broad, curved plates; tubercles in horizontal rows, some continuous vertically, all largest actinally, very regularly placed, perforate and very slightly crenulate or uncrenulate, in flat or depressed areas surrounded with circles, squares, or hexagons of miliaries.

Peristome large, decagonal; branchial incisions large, sometimes

broader than long. Jaws exist. Perignathic girdle with ambulacral processes, discontinuous. Periproct very large or moderate, placed between the apical system and the ambitus of the odd interradium, and at some distance from this; oblong, pyriform or irregular in shape, flush; may be in contact with the apical system, or a portion of the posterior interradium may intervene. Spines short and striated.

*Fossil.* Oolites: England, Europe. Cretaceous: Europe.

In *Pygaster megastoma*, Wright, the periproct intrudes so much, that the four basals are in a semicircle anteriorly, and the madreporite is not central, but restricted to its normal basal; the posterior radial plates are widely separated. Probably it should enter *Galeropygus*, Cott.

GENUS PYGASTRIDES, Lovén, 1887, *Bih. till Kongl. Sv. Vet.-Akad. Handl.* Bd. 13, Afd. iv. no. 10, p. 13.

Syn. *Pygaster*.

The periproct is dorsal and posterior.

Ambulacral plates all simple, the first plates broad, uniporous, carrying distinct, separate auricles. Poriferous zones simple, straight. Spheridia single.

Interradial peristomial plates single and broad. Tubercles perforate and crenulate, the primaries the largest. Ornamentation (epistroma) luxuriant.

*Recent.* Caribbean Sea, near Virgin Islands, 200–300 fms.

The species was founded by Lovén upon one imperfect specimen which only measured 3·5 millim. in length and 2·16 in height. But under the hands of the experienced teacher its structures were described and admirably drawn. The uniporous ambulacra and the solitary interradial plates at the peristome, coupled with weak ambulacral perignathic processes and the anus close to the apical system, characterize the genus, which Lovén has placed among the Echinoconidæ, *auct.* It is a very aberrant form, and the solitary specimen is defective.

## Section II.

GENUS DISCOIDEA, Klein, 1734 (Discoides), *Nat. Disp. Echin.* p. 26, pl. xiv. Gray, 1825, *Ann. Phil.* p. 429. Desor, 1842, in Agassiz, *Monogr. d'Éch. viv. et foss.* livr. 3, p. 50. Desor, 1858, *Synopsis des Échin. foss.* p. 175. Cotteau, 1869, *Ech.*

*du Dépt. de la Sarthe, Suppl.* p. 412. *Cotteau, Péron et Gauthier*, 1879, *Ech. foss. de l'Algér.* fasc. 8, pl. xii. fig. 2. *Duncan & Sladen*, 1886, *Journ. Linn. Soc.* vol. xx. p. 48. *Lovén*, 1874, *Études*, pl. xiv. fig. 125 ; 1888, *Bihang till K. Sv. Vet.-Akad. Handl.* Bd. 13, Afd. iv. no. 10, p. 9.

Test moderate and large, circular or subpentagonal in marginal outline, flat actinally, hemispherical or conico-hemispherical above the margin.

Apical system small, subpentagonal, the five basal plates united ; the madreporite perforating some or all, genital ducts in all except the posterior ; radial plates small.

Ambulacra narrow, flush, except actinally, where they are slightly raised, apetalous, consisting of low primaries near the apex, with rare demi-plates: near the ambitus and actinally there are compound plates, made up of a large middle primary, carrying a tubercle, and an adoral and aboral demi-plate, their sutures convex towards the large primary plate ; or a large primary plate is associated with a small adoral demi-plate, the suture being convex abactinally. Pairs of pores very numerous, small, in simple series abactinally, becoming slightly biserial and crowded actinally. Primary tubercles small, crenulated and perforated.

Interradia with distinct median sutures ; tubercles small, perforate and crenulate, the vertical rows have larger tubercles near the median line than elsewhere.

Peristome small, funnel-shaped, its margin high up and formed by ambulacral plates and also by a single plate in three interradia, and by a double plate in two interradia. Perignathic girdle a raised oblique discontinuous ring, composed of interradial plates (a ridge), the upper surface flat or shelving.

Interradial plates within the actinal surface with radiating ribs. Periproct small, actinal, between the posterior margin and the peristome, its plates large posteriorly and reaching close to the anal opening. Branchial incisions indistinct.

*Fossil.* Cretaceous: England, Europe, N. Africa.

The morphology of *Discoidea subuculus*, Klein, necessitates the formation of a subgenus for its reception.

Subgenus **ECHINITES** (*non auctorum*).

Test small, tumid actinally and at the margin, subhemispherical above.

Apical system with the madreporite in basal plate No. 2 only. Ambulacra with greatly crowded low primary tubercles.

Interradia crowded with small tubercles, the line of the transverse coronal sutures furrowed. Ribbing of plates within slight. Perignathic girdle ill developed.

*Fossil.* Cretaceous: England, Europe.

Genus CONOCLYPEUS, *Agassiz*, 1839, *Éch. Suisse*, vol. i. p. 63. *Desor*, *Synopsis*, 1858, p. 318. *Zittel*, 1879, *Handb. d. Pal.* vol. i. pp. 515-516. *De Loriol*, 1880, *Monogr. des Éch. Numm. de l'Égypte*, p. 80; *Palæontographica*, 1881, *Eocäne Ech. aus Ägypt. u. d. Lib. Wüste*, p. 14. *Duncan & Sladen*, 1882, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, pp. 51, 94, 124. *A. Agassiz*, 1883, 'Blake' *Ech.* p. 49 (*Amended.*)

Test large, thick, more or less oval in marginal outline, conical, vaulted, swollen or subconical dorsally, rather flat actinally, rising somewhat suddenly from the margin.

Apical system central or slightly excentric in front, small, projecting, with four basal plates; the madreporite in the right anterior basal, intruding also on the other basals, occupying the centre of the system, and separating the posterior radial plates; five small radial plates.

Ambulacra long, open, with broad poriferous zones nearly as far as the ambitus, thence gradually diminishing in breadth to the peristome, flush, or slightly sunken, or raised. Plates numerous low and broad primaries, rarely some demi-plates near the peristome. Pores wide apart and in pairs where the zones are broad, the inner pore circular in outline, and the outer more or less elliptical or comma-shaped; pairs gradually increasing in breadth and then diminishing, separated by costæ. Below the parts of the ambulacra with paired pores others are continued to and over the ambitus to the peristome, as a single series, a pair rarely being seen near the peristome and then it is due to the presence of a demi-plate. Phyllodes do not exist. Interporiferous areas broad, often projecting.

Interradia large, but narrow at the summit, and consisting of broad plates which are much higher than those of the ambulacra; projecting into the peristome.

Peristome central, moderate, pentagonal, elongate transversely, with well-marked bourrelets and no phyllodes. A ring-like

perignathic girdle with rather tall interradiial ridges and jaws\*. Periproct inframarginal, oval and longitudinal.

Ornamentation of the ambulacra similar to that of the interradia, small, very equal, of small perforate and crenulate primaries in sunken scrobicules and intermediate granular epistroma; costæ ornamented.

*Fossil.* Cretaceous: Europe (?). Eocene: Europe, Africa, Asia †.

*Genera incertæ sedis.*

Genus GALEROPYGUS, Cotteau, 1856, *Bull. Soc. Géol. de France*, sér. 2, vol. xiii. p. 648, & 1858-9, vol. xvi. p. 289.

Syn. *Galeopygus*, Desor, Synopsis, 1858, p. 167; *Centropygus*, Ebray.

Large depressed Urchins, circular at the slightly swollen margin, except posteriorly, where the edge of the test is thin and truncated.

Apical system central, or excentric in front, closed in front and open behind, with four basal plates contiguous and perforated; the madreporite in the usual basal, which is the largest. The anterior and the right antero-lateral radial plates outside, the others in contact with the periproctal groove. A groove containing the periproct entering the apical system and separating the posterior radial plates, the postero-lateral basals, and reaching the left anterior radial plate and the anterior pair of basals. The groove passes down to the posterior truncation, and the periproct is partly within and partly outside the apical system.

Ambulacra narrow, flush, straight, except the postero-lateral, which are more or less curved abactinally. Pairs of pores in simple series. Tuberculation of the test small, rather distant, homogeneous. Peristome central, decagonal, with branchial incisions. Spines subulate, striated, short. Neither perignathic girdle nor jaws have been seen.

*Fossil.* Oolite: England, Europe.

\* A specimen in the British Museum shows the perignathic girdle rubbed down, and a vertical section in another specimen shows the interradiial projection or ridge. There is no process connected with an ambulacrum, but the interradiial ridges are well developed. The girdle resembles that of *Discoidea* somewhat.

† The genus *Phylloclypeus*, De Loriol, absorbs the old *Conoclypei* with floscelles and no teeth.

Genus *PACHYCLYPEUS*, Desor, 1858, *Synopsis*, p. 198. Cotteau, 1867-74, *Pal. Franç., Éch. Terr. Jura*, vol. ix. pl. 101.

Test large, thin, ovoid in marginal outline, tumid above.

Apical system compact?

Ambulacra flush, apetaloid, similar, becoming wider towards the margin and contracting towards the peristome; pairs of pores in simple series.

Peristome central, in a depression, indistinctly decagonal. Periproct supra-marginal and at the posterior surface. Tubercles irregularly distributed.

*Fossil*. Oolite: Europe.

It is a very unsatisfactory genus and must be placed amongst the doubtful series.

#### Order IV. CLYPEASTROIDA.

The suborder Clypeastridæ was, as A. Agassiz remarks in his 'Revision of the Echini,' p. 504, limited by his father. The characters of the group are sufficiently determined in the 'Prodrome d'une Monog. des Radiaires,' 1836. But the morphology of the suborder was accurately described by J. Müller in his celebrated work on the structure of the Echinodermata ("Bau d. Echinodermen," Abhandl. d. könig. Akad. d. Wiss. Berlin, pub. 1854, p. 123); and many very important points in the anatomy were also explained by Lovén, in his *Études* (Kongl. Svenska Vetenskaps-Akad. Handl. Bd. xi. no. 7, 1874, pp. 32 & 47).

Lovén recognized the name given by L. Agassiz and wrote the first perfectly accurate and sufficiently synthetic definition of the suborder (*op. cit.* p. 32). It was evident from the examination of the recent and fossil forms which should come within the suborder that it would have to be split up into divisions of greater or less distinctness, and the types of *Clypeaster*, *Scutella*, *Laganum*, and *Echinocyamus* were noticed to present structural differences of unequal, but still of definite classificatory value. The question arose, were these types to represent families or subfamilies, and if the latter, how many families were to be recognized? A. Agassiz, in his 'Revision of the Echini,' divides the suborder into two families each containing subfamilies, and his first family is Haeckel's *Euclypeastridæ* (*Generelle Morphologie*, 1866). The subfamilies were *Fibularina*, Gray, for *Echinocyamus* and its allies, and the *Echinanthinæ* for *Clypeasters* (A. Agassiz wrote this last term with the family affix "idæ"). Now

it is certain from the construction of the ambulacra, the nature of the perignathic processes, the development of the internal supports of the tests, and the formation of the apical systems, that there is more than a subfamily distinction to be made between these groups. Again, *Laganum* is the type of a subfamily (Laganidæ, A. Agass.) of the same family Euclypeastridæ, but it departs extremely from the *Fibularina* and the *Echinanthus* of A. Agassiz. The Scutellidæ, the second family, have no subfamilies in the classification of A. Agassiz, yet *Arachnoïdes* and *Rotula* find a place in it as genera. It appears that the subfamily is made too prominent and at the expense of limiting the family in this classification.

After due consideration it appears that the types of the Clypeastridæ, mentioned above, should be representatives of families, and that the entire group is worthy of the same classificatory value and position as the Endocyclica with jaws. Claus may be taken as a writer having much experience, and in his 'Zoologie' he follows the method of A. Agassiz, but considers his suborder as an Order of the Class Echinides, the Echinodermata as a whole being a Type of Invertebrata.

It seems therefore advisable to call the Order—Clypeastroida, and to partly follow Agassiz and A. Agassiz, by establishing the families Fibulariidæ, Clypeastridæ, and Scutellidæ.

#### Order IV. CLYPEASTROIDA (p. 25).

Syn. *Clypeastridæ*, Agassiz (suborder), 1836. (Enlarged.)

Test either flat, or tumid, or rising dorsally, with a thin or tumid margin which may be notched; the internal floor and roof connected by calcareous pillars and partitions, limiting more or less the internal organs, and forming, or not, false walls as coverings to the water-system.

The apical system with a central madreporite; basal plates coalesced.

Ambulacra more or less polyporous; tentacles heteropodous. Petaloid parts of the ambulacra both with branchial and disciferous tentacles in the poriferous zones; usually very numerous simple small tentacles, each one in relation with a single pore, in the interporiferous areas, placed in simple or branching grooves, or along the transverse sutures or in the plates generally; tubular branchial tentacles at the peristome.

Interradia smaller than the ambulacra, may be disconnected,

freely perforated by small, single pores for small, simple tentacles actinally, and also more or less abactinally. Tubercles small, perforate, and crenulated. Open spaces or lunules may occur in the extra-petaloid parts of ambulacra and in the posterior interradium\*.

Peristome actinal, usually central; interradial marginal plates single; perignathic girdle discontinuous; processes narrow, either interradial or ambulacral. Jaws short, expanded, stellate in dorsal outline, the united pyramids without braces and compasses, projecting over the ambulacral areas; the teeth rarely more or less vertical, mostly horizontal; the jaws resting upon perignathic processes, or having them beyond their re-entering margin; retractor muscles only. Periproct beyond the apical system, excentric, either actinal, marginal, or dorsal in the posterior interradium. Spheridia few, covered.

*Family* FIBULARIIDÆ.

CLYPEASTRIDÆ.

LAGANIDÆ.

SCUTELLIDÆ.

Family FIBULARIIDÆ, (subfamily) *Gray, 1855, Cat. Rec. Ech. Brit. Mus.* pt. i. p. 27. (*Amended.*)

Small Clypeastroida with rudimentary, widely open, few-pored petals; jaws rather high; teeth superior and slanting. Perignathic processes broad, low, one on each interradium. Interradia small, with a single apical and a single peristomial plate, continuous\*. Periproct usually actinal. Slightly developed vertical partitions within the test, actinally limiting the ambulacra at their sides, radiating towards the peristome. A spheridium in each ambulacrum, covered.

Genus *Echinocyamus*.

Subgenus *Scutellina* (genus), Agassiz.

Genus *Sismondia*.

*Fibularia*.

*Runa*.

*Moulinsia*.

*Rotuloidea*.

Genus ECHINOCYAMUS, Van Phels. 1774, *Brief*. Leske, 1778, *Addit. ad Klein.* p. 213. Agassiz, 1841, *Monogr. d'Éch. viv. et foss.* livr. 2, p. 125. A. Agassiz, 1874, *Revision*, p. 304. Lovén, 1874, *Études*, pls. xvi. & xlv.

Test small, thick, pyriform or subcircular in outline, tumid and

\* See "Definition of terms," in the last chapter of this 'Revision.'



slightly convex abactinally, concave actinally near the central peristome.

Apical system central; sutures fused; madreporite central, with only one large pore; four genital pores; radial pores variable in size.

Ambulacra broader than the interradia, short where slightly petaloid, widely open distally; pairs of pores few and increasingly far apart; the horizontal sutures beyond the petaloid part, pierced by pores, some pores in the plates near the peristome.

Interradia narrow, continuous, a single broad plate in each, at the peristome and also at the apical end.

Peristome central, pentagonal. Perignathic ridges tall, broad, one on each peristomial interradiial plate. Jaws small; pyramids rather high, flat; teeth superior, inclined. Periproct between the peristome and the posterior edge of the test; anal plates four or five, triangular. Ornamentation of uniform small perforate tubercles, carried over the apical system. Spines short and slender. Within the test are five pairs of partitions limiting the ambulacra, for a short distance. A single spheridium in each ambulacrum, covered.

*Fossil.* Cretaceous to Miocene: Europe. Pliocene: England and Europe. Nummulitic: Asia and Africa.

*Recent.* N. Atlantic and British Seas, Norway, Azores, Josephine Bank, Mediterranean, Florida, Caribbean Sea. Littoral to 105 fathoms.

Subgenus SCUTELLINA, (genus) *Agassiz*, 1841, *Monogr. d'Ech. viv. et foss. livr. 2, Les Scutelles*, p. 98.

Test small, circular in outline. Jaws broad, low; pyramids horizontal; teeth superior. Periproct small, variable, marginal, or more or less supra- or inframarginal.

*Fossil.* Tertiary: Europe.

Genus SISMONDIA, *Desor*, 1858, *Synopsis*, p. 225. (*Enlarged.*)

Test of small or medium size, subpentagonal or ovoid, depressed, inflated at the margin.

Apical system central or subcentral, flush; only a single pore of the madreporite is present; four basal plates and their pores are large; radial plates small, pores minute.

Ambulacra, petaloid parts usually long, more or less open; pairs of pores few, not continued actinally; a great number of

minute pores occupy the transverse sutures of the plates actinally, and some are in the vertical sutures between the ambulacral and interradial plates. Interradial areas supported internally by a pair of strong, complex, vertical partitions, and the other parts of the test, within, bristle with projections.

Peristome central, sunken or not. Periproct actinal, between the peristome and the posterior margin. Tuberculation minute.

*Fossil.* Eocene: Europe, Africa, and Asia. Miocene: Europe.

A good series of drawings of a *Sismondia* will be found, by Sladen and Foord, in Monogr. Foss. Ech. Sind, pt. iii. pl. xxv., Pal. Ind. ser. xiv. 1884. They may be compared with the drawings of two species of *Echinocyamus* which are upon the same plate. The *Sismondia* differs in the more definite plating of the apical disk and the longer and more shapeful ambulacra, which are, moreover, tumid. But the alliance is very close. It will be observed that there are several additions to the diagnosis of Desor, in the above definition.

Genus FIBULARIA, Lamk. 1816, *Hist. Nat. Anim. s. Vert.* vol. iii. p. 17. Gray, 1855, *Catal. Rec. Ech. Brit. Mus.* pt. i. p. 28. A. Agassiz, 1873, *Revision*, p. 506.

Syn. *Mortonia*, Gray (*non* Desor).

Test small, thin, ovoid or elongate-elliptical, regularly arched and tumid dorsally, or subspherical, tumid at the sides and actinally around the sunken peristome and periproct.

Apical system central; four genital pores.

Ambulacra short, with ill-developed, very open petaloid parts; pairs of pores very few, continued wide apart to the margin, not united by a groove.

Interradia with or without the middle of the plates being raised.

Peristome small, pentagonal, sunken. Minute concentric plates in the peristomial membrane. Jaws high, stout or slender; teeth superior, sloping; perignathic processes large. Periproct actinal, sunken, nearer the peristome than the posterior margin, may be longitudinal and oblong. Internal structure of the test very simple, supports very rudimentary or absent, limiting the ambulacra near the edge. Tuberculation distinct, regular, or more distant actinally.

*Fossil.* Upper Cretaceous: Europe.

*Recent.* Mediterranean, Red Sea, Indian Ocean, Japan, Sandwich Islands, Philippines, Australian seas.

The next genus is not a satisfactory one.

Genus RUNA, *Agassiz*, 1841, *Monogr. d'Éch. viv. et foss.* livr. 2, *Les Scutelles*, p. 32.

Test very small, depressed, faintly arched dorsally, subcircular or ovoid at the thick, deeply incised margin.

Apical system central; four genital pores.

Ambulacra large, separated from the interradia by grooves dorsally and at the margins by incisions; petals short, widely open and everted distally; faint median groove actinally.

Interradia small.

Peristome circular, elliptical, central. Periproct small, between the peristome and the posterior margin.

*Fossil.* Tertiary: Europe.

A. Agassiz and Lütken consider *Moulinia* = *Moulinisia*, Agassiz, 1841, *Monogr. d'Éch. viv. et foss.* livr. 2, *Les Scutelles*, p. 139, tab. 22, to be synonymous with *Encope*, the young forms of this genus greatly resembling the species of *Moulinisia*. But if the figures given by the elder Agassiz be compared with those of A. Agassiz, it will be seen that there is much more general scolloping of the edge of the tests than is seen in the young (supposed) *Encopes*. R. Etheridge described a species from N. Africa which he placed in a genus *Rotuloidea*, and it shows the least possible anterior lobing. Under the circumstances it is best to consider *Moulinisia* and *Rotuloidea* as two closely allied genera.

Genus MOULINSIA (*Moulinia*), *Agassiz*, 1841, *Monogr. d'Éch. viv. et foss.* livr. 2, p. 139, tab. 22. *Desor*, 1848, *Synopsis*, p. 222. *Gray*, 1855, *Cat. Rec. Ech. Brit. Mus.* p. 27.

Test small, thin, very depressed, oval, slightly tumid above the edge, but flat dorsally. Margin lobed on account of the grooves along the median lines and between the ambulacra and interradia; some transverse grooving of the coronal plates.

Apical system small, central; five genital pores?

Ambulacra with petaloid parts widely open distally.

Peristome central. Periproct inferior, between the peristome and the posterior margin. Ambulacral pores not united by a groove. Tuberculation very distinct.

*Recent.* Martinique.

Genus ROTULOIDEA, *R. Etheridge*, 1872, *Quart. Journ. Geol. Soc.* vol. xxviii. p. 98.

Test moderate in size, thick, very depressed, broadly ovoid, longer than broad, actinally slightly concave.

Apical system small, central, circular; madreporite large, central; the genital pores on its flanks.

Ambulacra subpetaloid, widely open, with rather broad poriferous zones; inner pores circular, outer elongate; and more or less tumid interporiferous areas; actinally five perforated furrows, ramifying towards the margin.

The interradia larger than the ambulacra.

Anterior margin of the test smooth and slightly acute; posterior margin broader and with many (12) fimbriations continued actinally as grooves. Neither lunules nor cuts.

Peristome central, pentagonal, sunken. Periproct small, between the peristome and the posterior margin. Tubercles equal, densely placed in areolæ.

*Fossil.* Miocene: N. Africa.

#### Family CLYPEASTRIDÆ.

Syn. *Echinanthidæ* (subfamily), A. Agassiz, 1872-74, Revision, p. 510.

Test small to very large, depressed, flat, to high; margin subpentagonal or subcircular, sharp to very tumid. Apical system central, the basal plates fused together, all perforated by the central madreporite; genital pores beyond. Petaloid parts of the ambulacra highly developed, usually unequal, the actinal furrows straight.

Interradia actinally discontinuous, one peristomial and two apical plates in each. Jaws large, tall, wide above, the teeth in vertical grooves on the inner part of the pyramids. Perignathic processes tall, narrow, two on each ambulacrum, fitting in below the jaws. Internal structure various, always with needles and pillars extending from floor to roof and expanding, placed so as to limit the ambulacra incompletely from the intestinal areas, extending considerably towards the peristome; there may or not be a development of the pillars close to the edge of the test, and a more or less complete fusion of them into partitions arranged concentrically, so as to form inner walls; there may be an inner wall to the ambulacra protecting and

forming the canals for the water-system; actinally the ambulacra and terradia much pierced by pores, less so dorsally. Tentacles heteropodous. Spheridia two, covered, in each ambulacrum.

Genus *Clypeaster*.

Subgenus *Monostychia*.

Genus *Diplothechanthus*.

*Plesianthus*.

*Anomalanthus*.

The generic name *Clypeaster* originated with Lamarck, Syst. Anim. s. Vert. 1801. Previously Breynius, 1732, 'Schediasma de Echinis Methodica disponendis,' p. 59, placed a genus *Echinanthus* as one of the seven into which the Echinoidea could be divided. His definition was, "*Echinanthus* est Echinus cujus apertura pro ore est prope centrum, pro ano in, vel ad marginem longissime ab ore distantem." This is completely inadequate, and it naturally led him to combine several forms within the group, which really have no generic resemblance or affinity. Breynius gave figures of his types, and it is perfectly evident that his first form of *Echinanthus* is a well-grown *Echinolampas oviformis*. (This was reproduced in after years by Klein, Nat. Disp. Ech. tab. xx. figs. c-d; compare with Breynius, tab. iv. fig. 1.)

A second form included resembles *Pygorhynchus*, and a third is a *Cassidulus*. Breynius gave no figure of a *Clypeaster* or of an *Echinanthus* as accepted by modern naturalists; but he refers to Rumphius, 1705, 'Amboinsche Rariteitkamer,' pl. lix. fig. D, stating that his figure of *Echinanthus* agrees with the type of Rumphius; but this last is a miserable figure of a fossil *Clypeaster altus*. Again, the figure in Rumphius's tab. xiv. fig. 3, is said by Breynius to represent an *Echinanthus*, but it is a Cassiduloid. However, Breynius refers to Sloane, Nat. Hist. Jamaica, t. ii. tab. 242. figs. 6-11, and states that the figures also relate to his *Echinanthus*. They are those of the tumid Clypeastroid. It is interesting to note that Breynius remarked that the teeth of this form differ from those of *Echinometra*, and that there are within the test "trabes perpendiculariter erectas."

It is clear that Breynius did not separate the toothless *Echinolampas* and Cassiduloids from the gnathostomous Clypeastroid. It is therefore useless to prolong the discussion regarding his priority.

Klein came next, and although he employed the figures of Breynius and added, *op. cit.* pl. xxix., capital figures of the supports

and double ambulacral floors of the tumid Clypeastroid, he did not employ the term *Echinanthus*. On the contrary, he called the forms (Nat. Disp. Ech. p. 28, pls. 17*a*, 18*b*, 19*a*) Sectio "Scutum," species *humile* and *altum*.

Linnæus called the tumid Clypeastroid *Echinus reticulatus*; and Lamarck clearly differentiated the genus *Clypeaster* and included both the tumid and the flatter species in it.

Neither of these last-mentioned naturalists considered the genus *Echinanthus* of Breynius to be of any value.

In 1825 Gray resuscitated the term *Echinanthus*, but applied it not after the meaning of Breynius; he made it include the species termed *Clypeaster* by Lamarck. Neither Desmoulins nor Agassiz and Desor followed Gray, but considered Lamarck's generic term good and correct. However, in 1855 Gray called all Clypeastroids, both flat and tumid, "*Echinanthus*," in his Cat. Recent Ech. Brit. Mus.

In 1825 Gray had founded the genus *Echinolampas*, and in the Catalogue just referred to, p. 35, he again diagnosed that genus, and placed *Echinanthus* (see also under *Echinolampas oviformis*, Cat. Rec. Ech. Brit. Mus. p. 35) as a synonym. Here an error crept in, and palæontologists and zoologists have ever since employed *Echinanthus* in a different sense. The palæontologists, following the early part of the definitions of *Echinanthus* by Breynius, have associated the word with the Cassidulidæ; the zoologists have either associated the word with all the Clypeastroids, or have used it, following A. Agassiz, for the tumid Clypeasters especially.

Desor, in his Synopsis, 1858, associated the term *Echinanthus* with a well-differentiated group, having all the characters of that figure given by Breynius which has a *longitudinally elongate periproct placed supramarginal*—the figure which may have represented a *Pygorhynchus*. *Echinanthus* of Desor is a large genus, and it is impossible to state, with truth, that it is not *Echinanthus* according to Breynius.

The distinction between the internal construction of the flat and the concave based or tumid Clypeasters was shown by J. Müller in his 'Bau d. Echin.' 1854, p. 123. A. Agassiz, in his 'Revision,' was so struck with the value of J. Müller's discoveries, that he determined to make the tumid Clypeasters form a genus *Echinanthus*, which he attributed to Breynius. The whole subject is considered with the usual great care of the author of that 'Revision.'

and it does not appear that he will do otherwise than hold his ground.

A. Agassiz retains the Lamarckian name *Clypeaster* for the flat-based and more or less thin-edged Clypeasters, and it becomes of great importance to discover whether the internal structures of the tumid form are sufficient to necessitate its inclusion in a different genus.

This question was carefully considered before the publication of this Revision, and with the result that *Clypeaster* must remain as a genus, and that two genera must be founded, one to include the West-Indian *Clypeaster reticulatus*, Linn. sp. (*Echinanthus rosaceus*, A. Agassiz), and the other to be associated with *Echinanthus testudinarius*, Gray, from Australia.

*Anomalanthus*, Bell, is a fourth genus closely allied to *Clypeaster*.

It will be observed that *Echinanthus* is now removed from the Clypeastridæ and is placed amongst the Cassidulidæ, where Breynius certainly meant it to be in the first instance.

Genus CLYPEASTER, Lamk. 1816, pars, *Hist. Nat. Anim. s. Vert.* vol. iii. p. 12. Desor, 1858, *Synopsis*, p. 299. Lütken, 1863 (pub. 1864), *Vid. Medd. f. Nat. For. i Kjöbenh.* pp. 100, 132. A. Agassiz, 1872-74, *Revision*, p. 306. Duncan, 1885, *Journ. Linn. Soc., Zool.* vol. xix. p. 203, pl. 31. Lovén, 1887, *Ech. descr. by Linnæus*, pp. 171-176 (for synonymy).

Test variable in size, moderate to large, subpentagonal, ovoid, subcircular in marginal outline, usually truncated behind; edge thin, rarely slightly swollen, undulating in contour, with or without re-entering angles. Dorsum very depressed or tall, conical or subconical, or campanulate, and usually tumid centrally, and sloping to the margins. Actinal surface flat, and with the central peristome suddenly deeply sunken.

Apical system small, central, or slightly excentric; madreporite central, button or star-shaped; basal plates fused; genital pores close to the edge of the madreporite, or in the median interradaial sutures, five in number; radial plates small, and the pores also.

Ambulacra much larger than the interradia, the petals large, broad, long, tumid; poriferous zones broad, inclined, or narrow and short, nearly closing distally; plates low, broad, unsymmetrical, compound; the adoral component a primary and the aboral a low broad demi-plate; pores unequal, wide apart, with an intermediate groove; pores in the transverse sutures of the

tumid interporiferous areas. Beyond the petals and actinally, the pores are numerous and are oblique.

Small pores in great numbers in oblique transverse lines in the plates, to the peristome; actinal grooves straight, more or less developed, perforated. The second ambulacral plates from the peristome large and uniting around, so as to intrude upon the interradia.

Interradia narrow between the petals, the double apical plates may have a genital pore in their median sutures; a single plate at the peristomial margin; discontinuous actinally. Pores perforating the plates slightly abactinally and considerably actinally.

Peristome sunken, polygonal, thin-edged, with ten ambulacral and five interradial plates; buccal pores at the edge; two spheridia hidden in each ambulacrum. Perignathic girdle discontinuous, placed beneath the jaws; the processes tall, narrow, close, in pairs, arising from the edges of ambulacral plates. Jaws large; pyramids unequal, expanded dorsally; teeth in more or less vertical grooves placed on their inner surface; depressions below the pyramids for the articulation of the perignathic processes. Periproct infra-marginal, near or at the edge, posteriorly.

Within, numerous concentric partitions near the edge of the test, forming false walls, composed of fused or perfect needle-shaped or stout pillars expanding at the roof and floor; around the distal part of the petals and reaching to the floor are needles and supports expanding above and below, shutting off, incompletely, the ambulacral from the intestinal areas; this structure may extend some distance between the petals. The ambulacral plates with projecting ridges or needles, not coalescing to cover over the water-system or to form a double wall.

Tentacles of the petaloid part of the poriferous zones branchial and pectinated in whorls; the tentacles of the small pores prehensile, with a calcareous support to the disk. Pedicellariæ, some large stout-headed and narrow-ended tridactyles upon short calcareous stems; other pedicellariæ long, with narrow valves, or gemmiform and upon longer stems. Tubercles small, largest actinally, in sunken scrobicules, the intermediate structure with miliaries; ambulacral ornamentation smallest.

Spines very short for the size of the test, fine, cylindrical, largest and sometimes spathiform actinally.



*Fossil.* Tertiary: Europe, Africa, Asia, Australia, and N. America.

*Recent.* Red Sea, East-Indian Islands, New Caledonia, Philippines, Japan, Kingsmill Is., China Sea, Panama, San Diego, West coast of Africa, S. Carolina, Florida, Caribbean Sea, Brazil.

The huge, tall, bulky Tertiary species have flat actinal surfaces and are true Clypeasters. *C. altus* and *C. ægyptiacus* have short stout ridges upon the ambulacral plates of the petals, within the test, and they do not coalesce, or do so very imperfectly in places.

Subgenus MONOSTYCHIA, (genus) *Laube*, 1869, *Sitz. d. kais. Akad. d. Wiss. Wien*, p. 188; (genus) *Duncan*, 1887, *Quart. Journ. Geol. Soc.* vol. xliii. p. 417.

Test small, flat.

Apical system small; madreporite button-shaped; four genital pores; margin notched when young decidedly, and the peristomial ambulacral grooves straight and continued abactinally.

*Fossil.* Tertiary: Australia.

#### Genus DIPLOTHECANTHUS.

Syn. *Echinanthus*, Breynius, 1732, pars; Leske, 1778, pars; Linnæus, 1764, Mus. Lud. Ulrich. p. 714 (*Echinus reticulatus*, see Lovén, 1887, Ech. descr. by Linnæus, p. 174); J. Müller, 1853, Bau d. Echin., Abhandl. d. könig. Akad. d. Wiss. zu Berlin, pub. 1854, p. 123; Gray, 1855, pars; A. Agassiz, 1872-74, Revision, p. 310.

Test moderate and large, pentagonal or subcircular in tumid marginal outline, angles rounded; dorsum tumid variably; actinal surface tumid, but hollow from the margin to a deep central peristome.

Apical system small, madreporite star-shaped, central; the small radial plates at the re-entering angles, pores small, usually transverse; the basal plates fused; genital pores in the median sutures of the interradia, more or less remote.

Ambulacra with long, broad, tumid, almost closed petaloid parts, with the poriferous zones broad, slanting or depressed; the pores distant, unequal; the plates compound, the adoral component a large low primary, the aboral a small demi-plate; the wide interporiferous areas perforated; beyond the petals the plates are simple and larger, and are mainly perforated obliquely actinally.

The interradia small abactinally and sunken; discontinuous actinally, one plate entering the peristomial margin in each.

Peristome deep, its margin composed of ten ambulacral and five interradial plates, two spheridia in each ambulacrum hidden. Straight grooves in the ambulacra, and buccal pores at the margin of the peristome. Teeth, jaws, and perignathic girdle as in *Clypeaster*. Periproct at or close to the margin.

Internal structure without concentric partitions or false walls at the edge, or separate needles, expanded above and below near the edge, but with the petaloid parts of the ambulacra more or less limited by stout discontinuous septa or pillars which extend some way towards the apex, and are curved around the poriferous zones; the ambulacral and intestinal areas imperfectly separated. The ambulacra, with the exception of the poriferous zones, have an inner wall, produced by the coalescence of broad calcareous growths from the inner surface of the plates remote from their transverse sutures, and which, after reaching a certain height, expand and unite so as to form a wall standing upon low broad foundations; the raised foundations bound, and with the expansion form, the canals for the main and secondary water-systems of the ambulacra; foramina occur along the median line and near the poriferous zones. This inner wall supports expansions of pillars and needles.

Ornamentation small; tubercles sunken and surrounded with miliaries. Spines short, slender. Pedicellariæ, some very large, tridactyle and tumid-headed. Two hidden spheridia in each ambulacrum.

*Fossil*. Tertiary: West Indian Islands (Anguilla); San Domingo.

*Recent*. West Indian Islands, Florida. (Littoral to 5 fathoms.)

#### Genus PLESIANTHUS.

Syn. *Clypeaster*, Lamk. (pars); *Echinanthus*, Gray, 1855, A. Agass. 1872-4, pars.

Test with a tumid, subpentagonal margin, tumid and depressed dorsally, concave actinally; peristome deeply seated.

Apical system with a button- or star-shaped central madreporite; basal plates fused; genital pore beyond and in the median suture of the interradium; radial plates very small, pore circular or elongate.

Ambulacra with the petaloid parts long, tumid, broad, closed, or nearly so; poriferous zone broad, sloping or depressed, pores unequal, distant; plates compound, the adoral component a

primary, the aboral a small demi-plate; interporiferous areas broad, perforated. Pores of the non-petaloid parts oblique.

Interradia small, discontinuous actinally, more or less perforated, grooved or not. Peristome with ten ambulacral and five interradial plates, two hidden spheridia in each ambulacrum. Jaws and perignathic girdle as in *Clypeaster*. Periproct infra-marginal, in or close to the edge.

Internal structure with tall pillars, more or less united, and expanding at the roof and floor, placed so as to bound the ambulacra incompletely, and to reach some distance towards the centre of the test; some needles. Concentric partitions absent near the edge, and the inner wall of the ambulacra also.

Spines small, cylindrical, largest actinally, and sometimes spatulate.

*Recent.* Japan, Red Sea, Sandwich Islands, La Paz, Australia.

*Plesianthus* (= *Echinanthus*) *testudinarius*, Gray, sp., is the type.

Genus ANOMALANTHUS, *J. Bell*, 1884, *Proc. Zool. Soc. Lond.* p. 40.

Syn. *Echinanthus*, A. Agass. 1872-74, pars (see Rev. T. Woods, 1877-1878, *Proc. Linn. Soc. N.S.W.* vol. ii. p. 169).

Test large, ovoid in tumid marginal outline, high, swollen, flattened near the apex, which is slightly anterior. Peristome deeply sunken, grooves very slight.

Madreporite central, star-shaped; genital and radial pores variable in size.

Ambulacra apetalous, the poriferous zones abactinally broad, increasing in breadth to close to the margin, diverging gradually and becoming very wide apart, even tending to the lyrate form; pairs of pores very diverse in size, united by shallow grooves.

Periproct elongated transversely at the ambitus.

*Recent.* Australia.

It is interesting that there should only have been one large and mutilated specimen of the species "*tumidus*," Woods, but Prof. J. Bell made the most of his opportunity. There is a true *Clypeaster* in the Eocene of Kutch (Kachh) which has lyrate-shaped semi-petals (Duncan and Sladen, 1883, *Monogr. Tert. Ech. Kachh and Kattywar*, Pal. Indica, ser. xiv. p. 11).

Family LAGANIDÆ, (subfamily) *A. Agassiz, Revision,*  
1872-74, p. 516. (*Enlarged.*)

Test flat, with swollen or thin edges; the petals more or less unequal, narrow, lanceolate, moderate in length, ambulacra beyond them very wide; pairs of pores for branchial tentacles few, and between them are minute pores for prehensile tentacles, of which there are also multitudes in the interporiferous areas. Interradia small, each with a single apical and peristomial plate, continuous. Simple straight actinal grooves in the ambulacra, perforated, and with a buccal process and buccal pores. Periproct between the peristome and the posterior margin. Jaws small, rather high, the teeth superior and slanting. Perignathic processes (ridges) single on the interradian peristomial plates, situated so as to be beyond and not below the jaws. Internal structure of several pillars forming discontinuous concentric partitions close to the edge of the test, and of partitions limiting the ambulacra.

It is proposed to absorb the genus *Rumphia* and the subgenus *Peronella*.

Genus *Laganum*.

GENUS LAGANUM, *Klein, 1734, Nat. Disp. Ech.* edit. Paris, 1754, p. 92. *Gray, 1825 (Lagana), Ann. Phil.* n. s. vol. x. p. 427. *Agassiz, 1841, Monogr. d'Éch. viv. et foss.* livr. 2, *Les Scutelles*, p. 105. *Gray, 1856, Cat. Rec. Ech. Brit. Mus.* p. 8. *A. Agassiz, 1873, Revision*, p. 516. *Lovén, Études*, 1874, pp. 47, 83. *J. Bell, 1883, Ann. Mag. Nat. Hist.* vol. xi. ser. 5, p. 130. *Duncan, 1885, Journ. Linn. Soc., Zool.* vol. xix. p. 206, pl. 31. (*Amended.*)

Syn. *Rumphia*, Desor, 1858; *Polyaster*, Michelin; *Michelinia*, Duj.; *Peronella*, A. Agassiz.

Test moderate in size and large; subpentagonal or ovoid at the swollen or thin margin, truncated posteriorly, longer than broad, very depressed dorsally, flat or slightly concave actinally.

Apical system small, more or less stellate; madreporite central, with or without a curved furrow, into which enter a few water-pores; genital pores four or five, upon the flanks of the madreporite.

Ambulacra much larger than the interradia, but with the petaloid parts rather narrow, moderately long, nearly closed distally, plates simple; poriferous zones with minute simple pores in a transverse row between the consecutive large pairs;

interporiferous areas with very numerous transverse rows of pores for minute tentacles; actinally and at the peristome is a short groove, straight and perforate; buccal pores large. A single spheridium, covered, in each ambulacrum.

Interradia narrow; abactinally the highest plate is single, and actinally the plates are continuous, and the peristomial plate is single.

Peristome small, central, polygonal, formed by ten ambulacral and five interradial plates. Jaws well developed, with the teeth superior and more or less inclined. Perignathic processes single; interradial, short, bent, placed beyond the limits of the pyramids.

Periproct small, inframarginal.

Pillars and partitions only in concentric parallel series near the edge, within the test. Tubercles and surrounding miliaries scattered, similar, usually largest actinally. Spines short, dorsally cylindrical, slightly swollen, larger, longer, and cylindrical actinally, many around the peristome and periproct. Large slender tridactyle pedicellariæ near the petaloid parts of the ambulacra; others with expanded tops on projecting stalks very general.

*Fossil.* Tertiary: Europe, Asia, Java, N. Africa (Egypt), N. America.

*Recent.* East Indian Islands, Philippines, Pacific Islands, Japan, Persian Gulf, Red Sea, Mauritius, Zanzibar, Australia, Tasmania, New Zealand.

Family SCUTELLIDÆ, *Agassiz*, 1841, *Monogr. d'Éch. viv. et foss.* livr. 2, p. 1. *A. Agassiz*, 1872-74, *Revision*, p. 524.

Test very flat, margin incised or not, lunules or slits in the area or not. Ambulacral furrows bifurcating and branching. Peristome flush. Jaws flat, teeth superior. Radiating partitions between the floors internally.

Genus *Scutella*.

Subgenus *Echinarachnius*.

Genus *Echinodiscus*.

*Encope*.

Subgenus *Monophora*.

Genus *Mellita*.

Subgenus *Mellitella*.

*Astriclypeus*.

Genus *Lenita*.

*Mortonia*.

*Rotul*.

Subfamily *Arachninae*.

Ambulacral petals diverging; actinal grooves straight; no marginal cuts or lunules.

Genus *Arachnoides*.

Genus SCUTELLA, Lamarck, 1816, *Hist. Nat. Anim. s. Vert.* vol. iii. p. 7. Agassiz, 1841, *Monogr. d'Éch. viv. et foss.* livr. 2, *Les Scutelles*, p. 75.

Test moderate and large, much depressed, circular or sub-circular in outline, or undulating slightly or notched, broadest posteriorly, dorsally tumid, or subconical centrally, sloping to the thin edge.

Apical system central, more or less pentagonal; madreporite central; four genital pores at the edge of the projections; small radial plates and pores.

Ambulacra with the petaloid parts unequal, well developed, nearly closed; poriferous zones very broad, the inner pore large, the outer very small, and intermediate simple pores in the connecting groove; actinal grooves straight and deep near the peristome, bifurcating much beyond.

Peristome central, subcircular; buccal processes projecting. Jaws low, with rising laminae on either side of the superior horizontal teeth; pyramids unequal. Periproct small, infra-marginal. A homogeneous ornamentation of tubercles in hexagonal areas which are crowded with miliaries, largest actinally.

Within the test, flat pillars and partitions, forming discontinuous structures concentrically near the edge, and limiting the ambulacra for short distances.

*Fossil.* Cretaceous? : N. America. Eocene, Miocene, and Pliocene: Europe.

Subgenus ECHINARACHNIUS, Leske (genus), 1778, *Addit. ad Klein*, p. 218. Gray, 1825, *Annals of Phil.* vol. x. p. 6 (genus). *E. v. Martens*, 1865 (Scutella), *Monatsb. d. könig. Akad. d. Wiss. Berlin*, p. 140. *A. Agassiz*, 1872-74, *Revision*, p. 315 (subgenus). *Lovén*, 1874, *Études*, p. 50.

Syn. *Dendraster*, Ag.; *Scaphechinus*, Barn.; *Chaetodiscus*, Lütke.

Apical system excentric in front or behind.

Ambulacral petals large, long, unequal, open or tending to close; poriferous zones broad; pores and prehensile tentacles in the zone between the branchial tentacles; actinal furrows simple, narrow, and perforated near the peristome, bifurcating and

branching further out; the median furrow continues to the margin and may also be abactinal.

Interradia narrow, but the two apical plates do not embrace the genital pores, which are on the flanks of the madreporite; actinally the posterior interradium is discontinuous in the adult. Perignathic processes single, upon an interradial peristomial plate.

Peristome central, its margin composed of ten ambulacral and five interradial plates; buccal tentacles large, simple.

Periproct actinal, marginal or supramarginal. Marginal pedicellariæ bifid. A single covered spheridium in each ambulacrum.

Internal structures close, broad, concentric, discontinuous partitions and pillars, which radiate from points and occupy much space near the inner edge; more or less continuous partitions limiting the ambulacra for some distance inwards.

*Recent.* Both sides of N. America, Japan, Kamtschatka, Australia, New Zealand, Indian Ocean, Red Sea.

Genus ECHINODISCUS, Breynius, 1732, *Schediasma*, p. 63, tab. vii. (pars). Agassiz, 1841, *Monogr. d'Éch. viv. et foss.* livr. 2, pp. 62, 72; Gray, 1855, *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 19. A. Agassiz, 1873, *Revision*, p. 531.

Syn. *Amphiope*, Agass., 1841; *Lobophora*, Agass., 1841.

Test moderate and large, thin, flat, slightly raised dorsally, subcircular, widest posteriorly and truncated there. Two lunules or slits posteriorly, one in each of the median lines of the posterolateral ambulacra; lunules long, narrow, or broad and circular.

Apical system central or slightly anterior. Madreporite central, large, stellate; four genital pores beyond; radial plates small. Ambulacral petals small, broad, unequal, closed; the poriferous zones very broad; actinally the grooves are single near the peristome, perforate, wavy, and they soon bifurcate and again near the margin; a buccal process in each groove near the peristome.

Interradia narrow, the two apical plates of each having a genital pore in their median suture.

Peristome small, central, lobed or subpentagonal. Jaws flat, stellate, teeth horizontal, placed above the perignathic processes, which are single in each interradium and low and oblique. Periproct small, actinal, nearer the posterior edge of the test than the peristome.

Internal structure with the central space free, and beyond to the inner edge there are stellate networks of cellular supports

and of pillars. Actinal tubercles larger than the abactinal and the spines also, those of the dorsum are clavate.

*Fossil.* Tertiary: Europe, Africa, Asia.

*Recent.* Japan, E. coast of Africa, Red Sea, Madagascar, Java, Philippines, New Caledonia.

Genus ENCOPE, *Agassiz*, 1841, *Monogr. d'Éch. viv. et foss.* livr. 2, *Les Scutelles*, p. 45. *Michelin*, 1851, *Rev. et Mag. Zool. France*, p. 99. *Lütken*, 1863 (pub. 1864), *Vid. Medd. f. Nat. For. Kjöbenh.* pp. 111 and 133. *Verrill*, 1867, *Notes on Radiata*, p. 309. *A. Agassiz*, 1872-4, *Revision*, pp. 126, 324, 544. *Lovén*, 1874, *Études*, p. 47.

Test moderate and large, very depressed, slightly arched dorsally, flat actinally; marginal outline variable, circular, elliptical, ovoid or subpentagonal, may be broader than long or the reverse, more or less truncated behind. A broad notch of greater or less length, or a lunule in the median lines of the ambulacra, and a lunule in the posterior interradium.

Apical system central, or excentric in front; madreporite more or less stellate in outline, the five genital pores outside of it; the radial plates small and the pores minute on its sides.

Ambulacra divisible into a bivium and trivium; the posterior petaloid parts the longest, very nearly closing, with very broad poriferous zones; inner pores large, others small in very narrow grooves. Actinally the ambulacral grooves are perforated, bifurcating and branching towards the margin. The second ambulacral plates of all the zones are large, and unite so as to form a ring around the peristome, which is composed of ten small ambulacral plates and five interradial plates.

Interradia very narrow abactinally, the highest pair of plates narrow and including the genital pore in the median suture; actinally discontinuous, a single peristomial plate to each area.

Peristome small, subpentagonal; a single half-hidden spheridium in each ambulacrum. Periproct small, between the posterior lunule and the peristome, or entering the lunule.

Inside, the test is very cellular, and there is a more or less continuous area with pillars and partitions, some concentric or radiating from many points near the edge within; cellular structure separating the poriferous zones of the ambulacra from the intestinal tract and reaching inwards; a corresponding structure becoming lamellar in the interporiferous areas, and another surrounding the jaws.



Jaws small, stellate; teeth superior. Perignathic processes one on each interradius, low, narrow, bent. Spines short and cylindrical actinally, very small and ovate-headed dorsally.

*Fossil.* Miocene: Cuba.

*Recent.* W. coast of America, California, West Indies, Yucatan, Panama, Florida.

Subgenus *MONOPHORA*, *Agassiz*, 1847 (genus), *Bull. Soc. Géol. de France*, vol. iv. p. 287. *Cotteau*, 1884, *Bull. Soc. Zool. de France*, vol. ix. p. 340, pl. xi. *A. Agassiz*, 1874 (subgenus), *Ech. 'Hassler' Exped., Ill. Cat. Mus. Comp. Zoöl.* no. 8 (1), p. 13.

Test moderate in size, discoidal, with a thin, subcircular or slightly lobed margin, may be widest posteriorly; tumid dorsally, flat actinally. A single small lunule in the posterior median line.

Apical system central; madreporite large, genital pores on its flanks.

Ambulacra with nearly equal petals, which are short and nearly closed distally; poriferous zones broad; pores of pairs unequal, distant, separated by a long flexuous groove; beyond the petals the pores diverge and penetrate the wide ambulacral plates. Actinally, the ambulacral grooves are straight at the peristome and perforated, they soon bifurcate and may ramify further out.

Interradia narrow near the apical system, smaller than the ambulacra, the posterior with a small oval oblong lunule in the line of its median suture.

Peristome subcircular. Periproct small, not far from the peristome, and between it and the lunule. Tubercles abundant, close, small, smallest on the flanks of the ambulacral grooves.

*Fossil.* Miocene: Haut Parana and Patagonia, South America.

Genus *MELLITA*, Klein, 1734, *Nat. Disp. Ech.* p. 31, pl. xxi. (ed. Paris, 1754, p. 90, tab. xi. fig. c). *Agassiz*, 1841, *Monogr. d'Éch. viv. et foss.* livr. 2, p. 34. *Gray*, 1851, *Proc. Zool. Soc.* p. 36. *Michelin*, 1858, *Rev. et Mag. Zool.* p. 358. *Verrill*, 1867, *Notes on Radiata*, p. 312, and 1871, p. 588. *A. Agassiz*, 1872-4, *Revision*, pp. 140, 319, and 534.

Test moderate and large, very flat, slightly arched above, especially anteriorly, slightly concave actinally, edge rather sharp.

Marginal contour variable, subcircular, subpentagonal, narrow and long or the reverse, usually truncated posteriorly. Five or six lunules, usually closed, narrow and long, one in the median line of the posterior interradium, the others in the ambulacra, rarely developed as cuts.

Apical system variable in position, central or excentric in front, large, the madreporite central, the radial plates on its flanks, the four genital pores in the interradia.

Ambulacra petaloid abactinally, the posterior pair the longest, all nearly closed, with broad poriferous zones, pores distant; interporiferous areas tumid, plates very low. Actinally the plates are grooved simply and perforated near the peristome, the grooves bifurcate more than once towards the edge of the test. A single half-hidden spheridium in each groove near the peristome.

Interradia very narrow abactinally, the apically placed plates enclosing a genital pore in four areas; discontinuous actinally except in the posterior interradium.

Peristome small, central or excentric in front, with an ornamented margin; single interradiial perignathic processes, short, curved, bent backwards. Jaws above the processes, rather flat; teeth superior. Periproct small, at the proximal end of the interradiial lunule.

Simple pillars and close radiating partitions connect the upper and lower surfaces of the test near the edge inside, and extend inwards as solid partitions and separate the ambulacral and intestinal areas, and a cellular structure limits the jaws more or less. Spines club-shaped abactinally, spathiform near the edges of the lunules, actinally straight and long, and cylindrical and curved near the ambulacral furrows. Actinal tubercles rather large, with a raised warty intervening structure, abactinal tubercles smallest.

*Fossil.* Pliocene and Post-Pliocene: N. America.

*Recent.* Gulf of California, Panama to Peru, Galapagos, West Indies, N. and S. Carolina, Florida, Bermuda, Brazil; (Red Sea?).

#### Subgenus MELLITELLA.

All the ambulacral lunules as open slits in the margin. Genital pores four in number. Peristome and apical system excentric posteriorly.

*Recent.* Guayaquil, Panama, Galapagos.

To receive *Mellita Stokesi*, Agass., sp.

Subgenus *ASTRICLYPEUS*, *Verrill*, 1867 (genus), *Notes on Radiata*, p. 311. *A. Agassiz*, 1873, *Revision*, p. 538.

Syn. *Crustulum*, *Troschel*.

Test large, stout, depressed, circular in front, truncated posteriorly. Petals slightly unequal; poriferous zones broadest at the distal ends of the petals. Lunules long, narrow, the anterior the longest, all ambulacral; the interradial lunule wanting. The calcareous pillars separating the jaws from the intestinal region absent. Remaining internal structure as in *Mellita*.

Jaws flat, pitted inferiorly for the articulating processes of the girdle; teeth superior, short.

*Recent*. China and Japan.

Genus *LENITA*, *Desor*, 1847, *Catal. Rais.* p. 84; 1858, *Synopsis*, p. 222. *E. Forbes*, 1852, *Quart. Journ. Geol. Soc.* p. 342.

Test elongate, elliptical, depressed, only slightly tumid dorsally. Apical system with four genital pores.

Ambulacra with open petals; the pores barely conjugate.

Peristome circular, central. Periproct supramarginal. A broad, smooth antero-posterior actinal zone along the median line, flanked by large tubercles. Pillars and septa absent within.

*Fossil*. Eocene: Europe.

The next genus is of very doubtful value.

Genus *MORTONIA*, *Desor*, 1857, *Synopsis*, p. 231.

Test moderate in size, circular in outline, with a swollen edge.

Apical system with five genital pores. Ambulacral petals open.

Peristome central, and the periproct between it and the posterior margin of the test. Ambulacral grooves actinally dichotomizing and branching.

*Fossil*. Eocene: Alabama, N. America.

Genus *ROTULA*, *Klein*, 1734, *Nat. Disp. Ech.* p. 31, pl. 22 (ed. Paris, 1754, p. 94). *Agassiz*, 1841, *Monogr. d'Ech. viv. et foss.* livr. 2, *Les Scutelles*, p. 23. *Gray*, 1855, *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 16. *A. Agassiz*, 1873, *Revision*, p. 540. *Lovén*, *Études*, 1874, pp. 33, 83, pl. 46. fig. 238.

Test moderate and small, very flat, circular anteriorly, with

several short digitations, varying in length at the sides and posteriorly, with or without incisions, and two anterior lunules; slightly tumid dorsally, and flat or concave actinally.

Apical system small, central, tumid, stellate or not; radial plates small and with minute pores at the end of the limbs of the star; the four large genital pores within the system, rather close and separated by part of the madreporite or in grooves. Madreporite central and extending outwards; sutures not visible; fifth genital pore absent.

Ambulacra well developed, subequal, but divisible into bivium and trivium, long, subpetaloid, open distally, where the pores diverge and are continued irregularly to the margin; poriferous zones broad; pores large, except quite apically, with or without a line of intermediate minute perforations. In well-defined grooves at the peristome, perforated minutely, ending in a peristomial projection where there are large pores, grooves bifurcate into the digitations or not and in front. Spheridia, one in each peristomial groove, half covered.

Interradia very narrow at the apex and with one plate there; disconnected actinally, except in the posterior area and sometimes in area 3, on account of the dimensions of plates 2 of the ambulacra external to the peristomial series.

Peristome small, central, subpentagonal, with five slightly projecting ambulacral processes, surrounded by ambulacral and interradial plates.

Jaws short, small; teeth superior; perignathic processes interradial, single, small, low, hollow towards the pyramids.

Periproct small, circular, between the peristome and the digitations. Tubercles of the actinal surface very uniform, small and close; similar distribution abactinally.

Internal dissepiments wanting centrally; no septum between the ambulacral and intestinal areas; some needles in the digitations and extending inwards as columns or layers, but scanty in arrangement.

With or without two anterior lunules.

*Recent.* W. coast of Africa and Cape Verde Islands.

There are two sections of this small genus—(1) with lunules and intermediate ambulacral pores, the type of which is *R. Augusti*, Klein; (2) without lunules, *R. Rumphii*, Klein.

Subfamily *Arachninæ* (p. 158).

GENUS ARACHNOIDES, Breynius, 1732, *Sched. de Ech.* p. 64, tab. 7. figs. 7-8. Klein, 1734, *Nat. Disp. Ech.* p. 33, tab. 30. Agassiz, 1841, *Monogr. d'Éch. viv. et foss.* livr. 2, *Les Scutelles*, p. 94. Gray, 1851, *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 13. A. Agassiz, 1873, *Revision*, p. 528. Lovén, 1874, *Études*, p. 34.

Syn. *Asterodaspis*, Conrad; *Alexandria*, Pfeffer, 1880 (?).

Test thin, very depressed, outline circular, edge thin, slightly subconical dorsally.

Apical system central, tumid, the madreporite surrounded by radial plates and four or five genital pores.

Ambulacra very large, greatly exceeding the interradia in area, the petaloid portion with narrow poriferous zones very widely divergent and open distally; plates of petaloid part compound, an aboral demi-plate and a large adoral primary plate; the transverse sutures riddled with minute pores; actinally the plates form the whole of the peristomial margin or not; the ambulacral grooves straight, perforated by two buccal pores; with or without a process passing over the margin; and reaching the apex, imperforate. Two spheridia to each ambulacral groove near the peristome, hidden.

Interradia small, narrow apically, ending there with two plates, excluded from the peristome or not; not perforated by pores.

Peristome subpentagonal, central.

Jaws flat, with a crest and small rotulæ; teeth superior. The perignathic processes are stout, moderately tall and bent; there are two placed side by side on each peristomial interradial plate.

Periproct abactinal, near the posterior margin, small, circular. Tubercles of the ambulacra in oblique series; interradial tuberculation coarse, irregular, largest and least crowded actinally.

The internal structure of the test shows concentric rows of disconnected calcareous walls or calcareous pillars near the inner edge, branching and stellate nearer the middle of the test; neither partitions limiting the ambulacra near the margin, nor hard structures separating the ambulacral and intestinal areas.

*Fossil.* Pliocene: California.

*Recent.* Amboyna, N. Australia, Flinders Is., New Zealand, East Indian Islands, Burmah, Mergui.

*Alexandria*, Pfeffer, 1880, *Verhandl. d. nat. Vereins. v. Hamb.-Altona*, n. F. v. p. 63, appears to be an *Arachnoides* with a posterior notch.

## VI.

Order V. The Spatangoida. Suborder Cassiduloidea. The Family Echinoneidæ, Subfamilies and Genera. Genera incertæ sedis. Family Cassidulidæ and its Alliances and Genera and Subgenera. Family Collyritidæ and Genera. The Family Plesiospatangidæ and Genera.

## Order V. SPATANGOIDA (p. 25).

## Suborder CASSIDULOIDEA.

## ,, SPATANGOIDEA.

## I. Suborder Cassiduloidea.

Exocyclic nodostomes with a transverse or an oblique elliptical or irregularly shaped or pentagonal peristome; with or without "floscelles." Apical system either compact or elongate. Ambulacra abactinally simple, petaloid or subpetaloid, usually similar. Interradia, some or all, with a single peristomial plate; the postero-lateral areas symmetrical actinally, without any fusion of plates; no plastrons. Periproct in the posterior interradium.

## I. Family ECHINONEIDÆ.

Subfamilies *Echinoconinæ*, *Echinoneinæ*, *Oligopyginæ*, *Echino-brissinæ*.

## II. Family CASSIDULIDÆ. 180

## III. ,, COLLYRITIDÆ. 190

## IV. ,, PLESIOSPATANGIDÆ. 190

## I. Family ECHINONEIDÆ.

Cassiduloidea with variously-sized tests, ovoid or subpentagonal in marginal outline; tall, subconical, or subhemispherical, or low and tumid dorsally; tumid and rarely flat actinally. Apical system central, compact or subcompact, with four perforated basal plates. Ambulacra similar, moderate in width to narrow, dorsally apetalous or subpetaloid, rarely tending to close. Pores in simple pairs or rarely in oblique triplets actinally; no floscelle. Tentacles homoiopodous. Peristome oblique or transverse and elliptical, rarely symmetrical; the number of interradiial peristomial plates variable. Periproct actinal, marginal or supra-marginal.

This Family is subdivided into four subfamilies.

I. Subfamily *Echinoconinæ*.

Tall, conical or subhemispherical tests, rather flat actinally; the peristome more or less symmetrical; ambulacra with triplets of pairs of pores actinally; periproct submarginal or marginal.

Genus *Echinoconus*.

*Lanieria*.

Genus ECHINOCONUS, Breynius, 1732, *Schediasma de Ech.* p. 57, pl. 3. fig. 12. Desor, 1842, *Monogr. d'Éch. viv. et foss.* livr. 3, p. 7. *E. Forbes*, 1850, *Mem. Geol. Surv.* decad. iii. pl. viii. Cotteau & Triger, 1859, *Éch. de la Sarthe*, p. 279. Lovén, 1872, *Études*, pl. xv. Martin Duncan, 1884, *Geol. Mag.* p. 10. Lovén, 1887, *Bihang till Kongl. Svensk. Vet.-Akad. Handl.* Bd. 13, Afd. iv. no. 10 (Stockholm, 1888), p. 10. Duncan & Sladen, 1889, *Ann. & Mag. Nat. Hist.* ser. 6, vol. iv. p. 238.

Syn. *Galerites*, Lmk. 1816, *Anim. s. Vert.* vol. iii. p. 20; Desor, 1842. *Conulus*, Klein.

Test moderate, thin; oval, circular, or subpolygonal in marginal outline; tall, conical, subconical, or tumid and subhemispherical dorsally, flat or slightly tumid actinally.

Apical system small, compact, with four basal plates which are perforated; the madreporite in the right anterior, the basals 1 and 4 in contact and behind the madreporite, or slightly separated by one or by both of the posterior radial plates; antero-lateral radial plates separating the basal plates or not.

Ambulacra flush, or slightly raised, apetalous, straight; plates both low primaries and demi-plates, with larger primaries, some compound plates; pairs of pores small, in simple series abactinally and in oblique triplets actinally and close to the peristome. Interradia with a moderate number of broad, not very high plates.

Ornamentation of numerous small primary tubercles, and an epistroma of scattered distant sharpish granules.

Peristome central, sunken, slightly decagonal, symmetrical; some interradial marginal regions with one plate only; with an ascending, slightly developed tube; ten small, thick, buccal plates close to the margin. Perignathic girdle reduced to a thickening of the interradia as a low false ridge. Jaws none. Periproct marginal or submarginal.

*Fossil.* Cretaceous: England, Europe, N. Africa, Asia.

It does not appear that the interesting species first of all noticed by d'Orbigny, and redescribed by M. Cotteau, Desc. Éch. foss. de Cuba, 1881, in Ann. de la Soc. géol. de Belg. vol. ix. Mém. p. 11, pl. i., can enter *Echinoconus*. I have therefore defined a genus *Lanieria* for the so-called *Echinoconus Lanieri*.

Genus LANIERIA, gen. nov.

Test moderate, high, subglobular, slightly elliptical in marginal outline, broader than high, narrower and slightly tumid actinally.

Apical system central, projecting, pentagonal, with five basals largely perforated by genital ducts; madreporite in the right anterior, and also occupying the centre of the system and separating basals 1 and 4 and reaching basal 5. Radial plates entering the periproctal ring.

Ambulacra straight, narrow, flush, apetaloid; pairs of pores directly superimposed except actinally, where there is an arrangement of triplets in arcs. Tubercles of the interporiferous areas small, perforate and crenulate, larger near the poriferous zone, in two or more vertical rows.

Interradia large, with several vertical rows of primary tubercles, two of which reach the apex, scrobiculate and with granules between.

Peristome central, circular, slightly notched. Periproct rather large, elliptical, close to the peristome and reaching close to the posterior edge of the test.

*Fossil.* Cretaceous or Eocene: America (Cuba).

This genus admits *Galerites* = *Echinoconus Lanieri*, d'Orb.

II. Subfamily *Echinoneinæ*.

Tumid, low tests, more or less pulvinate actinally; peristome central or subcentral and oblique.

Genus *Echinoneus*.

*Amblypygus*.

*Caratomus*.

*Pygaulus*.

*Pyrina*.

Subgenus *Nucleopygus*.

Genus *Anorthopygus*.



Genus ECHINONEUS, Van Phelsum, 1774, *Brief aan Cornelius Nozeman*. Leske, apud Klein, 1778, p. 173. Desor, 1858, *Synopsis*, p. 197. Lovén, 1872, *Études*, pls. ix. and xv. A. Agassiz, 1872-74, *Revision*, p. 332. Duncan, 1884, *Geol. Mag.* p. 17.

Test small, thin, elongate-ovoid in marginal outline, tumid dorsally, flat actinally, depressed.

Apical system central, small, compact; four basal plates perforated by ducts, the posterior pair united, sutures fused, fifth basal absent; the madreporite in the right anterior basal. Radial pores very small.

Ambulacra similar, flush, apetaloid, narrow, broadest above the ambitus; poriferous zones narrow, straight, sunken or not; pairs of pores numerous, in straight series, some are in low primaries and others are in larger primaries associated with a small demi-plate also carrying a pair. Tubercles of the interporiferous areas crowded, sunken or not, small, simple, and without mamelons.

Interradia with crowded tubercles resembling those of the ambulacra; but many small, glassy, spineless tubercles of epistroma occur.

Actinally the ambulacra are unequally broad, in consequence of the obliquity of the triangular, rounded-angled, large, central peristome. This is longest between the interradia 2 and 4 and the edge of ambulacrum v. At the peristomial margin the interradia 2 and 4 have two plates, but all the others only have one. The actinal membrane is covered with pentagonal plates, which become more numerous towards the centre of the area and the small mouth.

Periproct inframarginal, large, long, oval, separated from the peristome by a single interradiial peristomial plate and the succeeding pair of plates. The membrane without tentacles. Periproctal plates large near the edge anteriorly. Spines short. Ambulacral tentacles homoiopodous, disciferous.

*Fossil.* Miocene: N. America. Late Tertiary: Guadeloupe, Cuba.

*Recent.* Caribbean Sea, Florida, Australia, Kingsmill Islands, Zanzibar.

Genus *AMBLYPYGUS*, *Agassiz*, 1840, *Catal. Syst. Ectyp. Echin. Mus. Neoc.* p. 7. *Desor*, 1858, *Synopsis*, p. 255. *Duncan & Sladen*, 1883, *Pal. Ind.* ser. xiv., *Foss. Ech. Kachh & Kat.* p. 12. *Duncan*, 1884, *Geol. Mag.* p. 17.

Test large, stout, ovoid or subpentagonal at the tumid ambitus, moderate or depressed in height, tumid and convex dorsally, more or less swollen actinally, around the peristome.

Apical system central or subcentral, small, four basal plates with large ducts, and perforated by the madreporite, which is largely in the right antero-lateral basal, and which may pass between the postero-lateral basals and even separate the posterior radial plates. Radial plates small.

Ambulacra narrow, flush or slightly raised, apetaloid, continuous from the apex to within the peri-stomial tube; poriferous zones expanding below the apical system and contracting before reaching the ambitus, thence becoming very narrow and consisting of a straight series of oblique small pairs; at the expanded part the pairs are separated by a raised costa, the inner pores are circular, the outer series being transversely elongate and the pores are connected by a groove. Plates are mainly low primaries, each with a pair of pores; but many are composed of a small demi-plate and a large primary combined.

Interradia broad; unequally broad at the peristome, where the plates are single in all the areas except 2 and 4, in which there are two peristomial plates; all these plates pass up slightly and form a kind of mouth-tube.

Tubercles of both areas very small, crenulated, distant, and separated by sharp epistromal granules.

Peristome large, oblique, the long axis between interradia 2 and 4, sunken, deep, widely open, irregularly triangular, with a long and short axis, subcentral. Periproct large, pear-shaped, its long axis in that of the test, situated near the peristome and between it and the posterior margin.

*Fossil.* Cretaceous: Cuba (?). Eocene: Europe, E. Africa, Asia. Tertiary: Jamaica.

Genus *CARATOMUS*, *Agassiz*, 1840, *Catal. Syst. Ectyp. Ech. Mus. Neoc.* p. 7. *Desor*, 1842, in *Agass. Monogr. d'Ech. viv. et foss.* livr. 3, p. 35. *Cotteau & Triger*, 1859, *Éch. de la Sarthe*, pl. xxxi. figs. 15-19.

Test small, depressed, ovoid or elliptical in tumid outline,

rather widest posteriorly; swollen dorsally, flat or pulvinate actinally, and may be subrostrated behind.

Apical system compact, with four basal plates well perforated; the madreporite large and extending backwards in the usual basal, separating the posterior lateral basals and touching the posterior radial plates which are in contact.

Ambulacra moderately broad, straight, flush, widest at the ambitus, narrowing dorsally and less so at the peristome; plates primaries, low, broad, each with a pair of pores; pairs of pores in simple straight series dorsally, continued to the peristome.

Interradia with a moderate number of plates with small ornamentation.

Peristome central and oblique, the long diameter being between ambulacrum v. and interradium 2, sunken. Periproct inframarginal and marginal, triangular, with rounded angles.

*Fossil.* Cretaceous: England, Europe, Africa.

There may be some backward prolongation of the peristome in some species of *Caratomus*, and in M. Cotteau's valuable memoir it appears that its long axis may be between amb. ii. and amb. iv.

The next genus is not a satisfactory one, for some of the species are barely separable from *Caratomus*, and there is some doubt about the generic position of the N.-African forms with semi-petaloid ambulacra.

Genus PYGAULUS, *Agassiz*, 1847, *Catal. rais., Ann. d. Sci. Nat.* vol. vii. p. 158. *Desor*, 1858, *Synopsis*, p. 251. *Cott., Peron & Gauth.* 1876 and 1884, *Éch. foss. de l'Algér.* new ed. of fasc. 2, p. 75.

Test small, thick, tumid at the ovoid or elliptical ambitus, low and slightly convex dorsally, pulvinate actinally, subrostrated posteriorly.

Apical system slightly excentric in front.

Ambulacra narrow, increasing in width to the ambitus and then diminishing; poriferous zones narrow; pairs of pores in simple series, and the shape of the pores of a pair may be different, and either circular or elongate transversely.

Peristome elongate, more or less oblique, and sunken, and the pairs of pores are very slightly crowded at the margin. Periproct inframarginal and ovoid-elongate or marginal.

*Fossil.* Cretaceous: Europe, N. Africa.

Genus PYRINA, *Des Moulins*, 1833, *Études sur les Éch.* p. 26.  
*Agassiz*, 1840, *Catal. Syst. Ectyp. Ech. Mus. Neocom.* p. 7.  
*Desor*, 1842, in *Agass. Monogr. d'Éch. viv. et foss.* livr. 3,  
 p. 25. *De Loriol*, 1873, *Éch. Helv. Crét.* p. 201, pl. 14;  
 1888, *Faune Crét. Portug., Éch.* vol. ii. fasc. 2, p. 78, pl. xvi.

Test small or moderate, ovoid, elongate, broader than high, tumid at the margins and swollen abactinally, may be pulvinate actinally.

Apical system compact, with four basal plates, the two posterior radial plates close together; madreporite large, in the large right anterior basal plate, reaching back but only to the edge of the posterior basals which are in contact; four generative pores and no fifth basal plate, or complementary plates may exist behind a small madreporite.

Ambulacra flush; poriferous zones narrow, widely open at the ambitus, apart yet closing much actinally. Pairs of pores numerous, small, and separated by costæ, non-conjugated, in simple series dorsally, more or less in oblique triplets actinally; plates primaries, low and broad, with demi-plates. Interradia broad.

Peristome nearly or quite central, elongate-elliptical, slightly oblique, the long axis being between zone *b* of amb. iii. and zone *a* of amb. i.

Ornamentation of both areas diffused and very equal, of sunken primary tubercles, crenulate and perforate, with large and small rounded granules on the intermediate structure.

Periproct pyriform, supra-marginal, elongate, but remote from the apical system.

*Fossil.* Cretaceous: England. Cretaceous and Eocene: Europe. Cretaceous: N. Africa.

Subgenus NUCLEOPYGUS, (genus) *Agassiz*, 1840, *Catal. Syst. Ectyp. Ech. Mus. Neoc.* p. 7. *Desor*, 1842, in *Agass. Monogr. d'Éch. viv. et foss.* livr. 3, p. 32; *Synopsis*, 1858, p. 188 *a*.

Test small, circular or oblong in tumid marginal outline, depressed, swollen above, subpulvinate actinally.

Apical system compact, with four basal plates and five radial plates all perforated, the posterior radials touch.

Ambulacra apetalous, straight; pairs of pores in simple series. Peristome circular or elliptical, but with a decagonal outline.

Periproct large, superior, more or less remote from the apical system.

*Fossil.* Oolite and Cretaceous: Europe.

It is an unsatisfactory genus, and probably will merge entirely into *Pyrina*.

De Loriol, 1888, *Faune Crét. du Portug.*, *Éch.* vol. ii. fasc. 2, p. 80, describes *Pyrina globosa*, which is inseparable from the genus, and obviates the necessity of retaining the genus *Globator*, Agassiz, 1880.

Genus ANORTHOPYGUS, Cotteau, 1859, *Éch. de la Sarthe*, livr. 4, p. 177, pl. xxxi. figs. 1-9; 1863, *Éch. Foss. des Pyrén.* p. 36. De Loriol, 1888, *Faune Crét. du Portug.*, *Éch.* vol. ii. fasc. 2, pl. xiii.

Test of moderate size, more or less swollen above, low; almost flat below; subpentagonal or circular in outline at the ambitus; sometimes subconical and moderately high, and slightly truncated behind.

Apical system central, compact, granular at the surface, with four basal plates and five radial plates. Madreporite large, in the right anterior basal, and separating the postero-lateral basals 1 and 4, occupying the position also of the posterior basal, and separating the posterior radial plates.

Ambulacra narrow; increasing in width to the ambitus, and then narrowing to the peristome. Poriferous zones simple, converging above, and pairs simply superposed.

Peristome elliptical, longest transversely in an opening in a deep impression on the actinal surface; branchial incisions small. No traces of jaws or a perignathic girdle. Periproct flush with the test, large, oblique, irregular, situated between the apex and the posterior margin. Tubercles of the areas small, perforated, crenulate and scrobiculate.

*Fossil.* Cretaceous (Cenomanian): Europe.

### III. Subfamily *Oligopyginæ*.

Tests with very small periproctal openings.

Genus *Haimea*.

*Oligopygus*.

The next genus is a very unsatisfactory one.

Genus *HAIMEA*, *Michelin*, 1851, *Rev. et Mag. de Zool.* p. 92.

Test small, moderately high, tumid and slightly elongate. Apical system nearly central and with four generative pores.

Ambulacra tumid, imperfectly petaloid, open, passing over the margin to the peristome; pores oblique.

Peristome central, pentagonal, and without bourrelets. Periproct very small, oval, and placed nearer the peristome than the posterior margin.

There is only one species to this genus, and the geological position is not known. In Michelin's figure the form is not larger than a nut, it is truncated posteriorly, and swollen and subspherical; it appears to be a figure of a cast.

*Fossil.* Distribution unknown. (Cretaceous?, France.)

Genus *OLIGOPYGUS*, *De Loriol*, 1887, *Rec. Zool. Suisse*, t. iv. no. 3, p. 394.

Test moderately large, thick, oval, elongate, depressed, tumid actinally.

Apical system central or subcentral, compact, small, four perforated basals; madreporite central and extending to the posterior radials; radial plates with very small pores.

Ambulacra slightly differing in length, otherwise similar, almost flush, semi-petaloid, widely open. Poriferous zones broad; pores equal.

Peristome central, elliptical, broader than long, in a concavity of the test; floscelle and jaws wanting. Periproct very small, circular, opening actinally between the peristome and posterior margin. Tubercles small, imperforate, scrobicules sunken.

*Fossil.* Tertiary: Florida, N. America.

#### IV. Subfamily *Echinobrissinae*.

Tests depressed, elongate, tumid. Ambulacra subpetaloid. Apical system and peristome excentric, the latter variable in shape, and with single interradiial marginal plates; floscelle absent or rudimentary. Periproct supramarginal.

Genus *Echinobrissus*.

Subgenus *Dochmostoma*.

*Oligopodia*.

Genus *Anochanus*.

*Botriopygus*.

*Ilariona*.

Few genera of the Echinoidea have received more attention than *Echinobrissus*, Breynius, and *Nucleolites*, Lamarek. They have been most satisfactorily and candidly studied by Cotteau and A. Agassiz during late years, and have been united by the last-named author. He has shown that the singularly insufficient character which was supposed to separate the genera, namely, the presence or absence of grooving between the pores of a pair, may be seen in the same petal of a specimen of a species.

The so-called conjugation of pores of a pair is of no physiological importance, and taken alone is of no classificatory value; but when it occurs with other characters it may assist to group sets of species together in a genus. The obliquity of the peristome is of greater importance, and, all other characters being the same, it is of subgeneric value; but if other characters of importance differ, the obliquity should be of generic value. But in *Echinobrissus* the obliquity is of subgeneric value, and relates to the forms which d'Orbigny, not very felicitously, called *Trematopygus*.

The possibility of retaining the recent species in the genus is a matter of doubt, and as they have modifications of the poriferous zones below the petaloid portions, they should come under a subgenus *Oligopodia*.

Genus ECHINOBRISSEUS, Breynius, 1752, *Schediasma de Echin.* p. 62. Gray, 1825, *Ann. Phil.* p. 7; 1855, *Cat. Ech. Brit. Mus.* p. 37. Milne-Edwards, 1836, *Cuvier's Règ. Anim.* ed. iii. Desor, 1858, *Synopsis*, pp. 257, 263. Zittel, 1864, *Novara Reise, Foss. Molusc. u. Ech. a. N. Zealand*, p. 62. A. Agassiz, 1872-74, *Revision of the Echini*, pp. 555 & 557. Cotteau, 1884, *Bull. Soc. Zool. France*, vol. ix. p. 336. Duncan, 1887, *Quart. Journ. Geol. Soc.* xliii. pp. 420 & 429. Bell, 1887, *Ann. & Mag. Nat. Hist.* ser. 5, vol. xx. p. 125.

Syn. *Nucleolites*, Lamarek, 1801; Agassiz, 1847, *Cat. rais.*, *Ann. des Sci. Nat.* vii. p. 153. *Trematopygus*, d'Orbigny.

Test rather thin, depressed, elongate, rounded in front, broadest and more or less truncated behind; or square, with the angles rounded; or subcircular; tumid above, concave actinally. Abactinally grooved posteriorly.

Apical system subcentral or excentric in front; four perforated basal plates; madreporite in right anterior basal, or extending into others, or separating the lateral basals of one side from

those of the other; usually the postero-lateral radial plates are in contact; or complementary plates may separate the postero-lateral basals and radials.

Ambulacra unequal, flush or slightly raised, open at the end of the subpetaloid parts; pairs of pores in simple series, more or less unequal in shape and size, the outer elongate; below the subpetaloid part the pores in small oblique pairs, conjugate or not.

Peristome excentric in front, deeply seated, pentagonal, elongate or rarely circular, elliptical, transverse or oblique; without bourrelets, and with very rudimentary or absent phyllodes, and only slight doubling of pores. Periproct usually elongate longitudinally, may be transverse, placed at the upper part of the posterior groove, which extends with variable lengths towards the apex; periproctal membrane with large plates near the edge. Tuberculation small, larger actinally.

*Fossil.* Oolite: England, Europe, Asia. Cretaceous: England, Europe, N. Africa, Asia. Eocene: Europe. Tertiary (late): Australia, N. Zealand, Java.

#### Subgenus DOCHMOSTOMA.

Syn. *Trematopygus*, (genus) d'Orb.

Peristome oblique.

*Fossil.* Cretaceous: Europe, N. America.

#### Subgenus OLIGOPODIA.

Ambulacral pores single below the petaloid part.

*Recent.* New Zealand, Madagascar, East Indian Islands.

Cotteau has probably seen and examined more species of *Echinobrissus* than any other palæontologist, and as far back as 1871 he gave an amended diagnosis of the genus in Pal. Franç., Terr. Jura, ix. p. 233. He noticed the variability of the position of the madreporite and of the periproct. Later, in 1884, the same careful observer (Bull. Soc. Zool. de France, p. 336) stated that, after a study of twenty-six species, he found that the madreporite in general touches the postero-lateral basal plates, and that sometimes it separates these plates, and it may even separate the postero-lateral radial plates; even complementary plates may separate the basal plates and the radials, these structures not being seen in all individuals of the same species. The periproct varies in its position from touching the apical system to



anywhere between the apical system and the posterior margin of the test.

These remarks dispose of the five genera or subgenera suggested by M. Pomel; M. Cotteau (*op. cit.* p. 336) writes that the characters depended upon for their separation are of specific value only.

We shall have to recur to this decision, in which we fully concur, further on in noticing the forms referred to *Hemiaster*.

It is certain that the typical species of *Echinobrissus*, as well as the recent forms, have no true floscelle, and this condition is exemplified in *E. Meslei*, Peron & Gauthier, from Algiers. But MM. Cotteau, Peron & Gauthier, and also M. Coquand, admit species into the genus which have bourrelets and phyllodes, such as *E. Juliéni*, *E. inaequiflos*, *E. sitifensis*, and others which are described in 'Éch. foss. de l'Algérie,' fasc. 7 & 8. These have well-developed phyllodes and all the characters of *Cassidulus*, except the unimportant actinal median bare band (see *Cassidulus*).

Genus ANOCHANUS, Grube, 1869, *Monatsb. d. k. preuss. Akad. d. Wiss. zu Berlin* (1868), p. 178.

Test small, resembling *Nucleolites epigonus*, Martens \*, in shape, and in the position of the peristome and periproct; having no visible madreporite or basal plates; the dorsum occupied by a marsupium which does not lead into the cavity within the test, but which is surrounded by a raised rim of calcareous tissue, lined with soft parts which bend in from the outer derm, and are covered with pedicellariæ and protected at the narrow external opening by spines; larger pedicellariæ on the outside of the test. The perfect young are found within the marsupium with spines on them.

*Recent.* Probably China.

Genus BOTRIOPYGUS, d'Orbigny, 1855, *Pal. Franç., Éch. terr. Crét.* p. 334. Desor, 1858, *Synopsis*, p. 278, pl. xxxi. De Loriol, 1873, *Pal. Suisse, Terr. Crét.* pl. xvi. fig. 3; 1884, *Rec. Zool. Suisse*, i. p. 615.

Test small and moderate, elongate ovoid at the narrow, tumid, somewhat undulating margin, broader behind than anteriorly,

\* *Oligopodia epigonus*, Martens, sp.

and more or less truncated, low and arched dorsally, flat or concave actinally; grooved or not posteriorly.

Apical system excentric in front, small, and with four perforated basal plates.

Ambulacra flush, unequal, long, open, and subpetaloid, the pores unequal; zones broad.

Peristome sunken, excentric in front, oblique, subpentagonal, with only slight doubling of pairs of pores, and no true floscelle. Periproct supramarginal, oval, elongate. Tubercles nearly equal in size throughout.

*Fossil.* Cretaceous: Europe, Asia (S. Hindustan), N. Africa.

GENUS ILARIONA, Dames, 1877, *Palæontographica*, n. F. i. (xxv.) p. 34.

Test elongately oval or oviform, subdepressed, more or less convex above, flat or slightly convex below; margins very thick or tumid.

Apical system compact, excentric in front.

Ambulacra petaloid; petals short, unequal, lancet-shaped, contracting and nearly closed. Poriferous zones equal; pores round or oval, conjugate.

Peristome decagonal or subdecagonal, with a raised rim and special tubercles. Floscelle absent. Periproct elongately oval, on the upper part of the posterior vertical truncation of the test.

Ornamentation very uniform; tubercles small, sunken in deep scrobicules, close; miliary granulation confluent and compact. A more or less bare band between the peristome and periproct.

*Fossil.* Eocene: Europe, Asia (Sind).

The peculiar and distinctive structure of the peristome was discovered and carefully pointed out by W. Dames. He notices (Ech. d. Vicent. u. Veron. Tertiär. p. 34, *Palæontographica ut suprâ*) the outline is decagonal, which might be represented by an equilateral pentagon from which the angles had been abruptly truncated by short lines—the long lines, corresponding with the interradia, being granular, whilst the short lines, corresponding with the ambulacra, are smooth. At the junction of the long and short lines a small smooth tubercle is present, the peristome being therefore surrounded by ten of these protuberances. The margin of the aperture is raised, and extends far into the body-cavity.

*Genera incertæ sedis.*

Genus *Desorella*.

*Oviclypeus*.

Genus *DESORELLA*, Cotteau, 1862, *Rev. et Mag. de Zool.* (pars); and 1867-74, *Pal. Franç., Ech. terr. Jura*, ix. p. 384.

Test of moderate size, subcircular in undulating ambital outline, subconical dorsally, pulvinate actinally.

Apical system absent, leaving a large scar; probably a large madreporite separated the posterior radial plates.

Ambulacra with simple pairs of pores, not doubling near the peristome.

Peristome subdecagonal, oblique or not, sunken. Periproct elongate, just supramarginal, large, pyriform, distant from the apical system.

*Fossil.* Oolite: Europe.

This is now a very unsatisfactory genus, and it formerly included *Pseudodesorella*, which is a well-defined genus. It has been determined from casts of species.

Genus *OVICLYPEUS*, Dames, 1877, *Palæontographica, Cassel*, Bd. xxv., *Ech. Vicent. u. Veron. Tert.* p. 44.

Test large, with an oval tumid margin, subhemispherical dorsally, slightly tumid actinally.

Apical system slightly excentric in front, small, with four genital pores.

Ambulacra similar, with wide poriferous zones extending to the ambitus and furthest apart there, diverging regularly from the apex downwards, diminishing in the distance of their pores at the margin of the test, showing no tendency to close. Pores circular, becoming slit-shaped with distance from the apex, wide apart and probably with a wide intermediate groove, lasting to the narrowest part of the zone; costæ with close miliaries. Interporiferous areas narrow, with numerous small, close primary tubercles, which are probably plain and scrobiculate. Actinally ten grooves extend from the margin to the peristome, producing the appearance of five compound grooves, each groove is a poriferous zone; no doubling of the pairs is seen.

Interradia tumid, wider than the ambulacra, crowded with similar small, scrobiculate, primary tubercles, some hexagonal.

Peristome slightly excentric in front, deeply sunken, the interradial margins projecting and tumid. Periproct marginal, moderately large, elliptical, with a downward projection.

*Fossil.* Eocene: Europe.

## II. Family CASSIDULIDÆ.

Cassiduloidea with very variably shaped tests; ambulacra petaloid, subpetaloid, or apetalous dorsally, and with crowded doubling of the pairs of pores close to the peristomial margin, forming with the single swollen and ornamented interradial peristomial plates "a floscelle."

This Family contains 27 types, and they may be grouped artificially around four genera.

Alliance of Genus *Cassidulus*.

Subgenus *Rhynchopygus*.

*Pygorhynchus*.

Genus *Stigmatopygus*.

*Echinanthus*.

Subgenus *Hardouinia*.

Genus *Eurhodia*.

*Paralampas*.

Alliance of Genus *Catopygus*.

Subgenus *Studeria*, subgen. nov.

Genus *Neocatopygus*.

*Phyllobrissus*.

Alliance of Genus *Clypeus*.

Subgenus *Clypeopygus*.

Genus *Pygurus*.

*Faujasia*.

*Galeroclypeus*.

*Pseudodesorella*.

Alliance of Genus *Echinolampas*.

Subgenus *Milletia*.

Genus *Phylloclypeus*.

*Conolampas*.

*Plesiolampas*.

Subgenus *Oriolampas*.

Genus *Palæolampas*.

*Microlampas*.

*Neolampas*.

A. Agassiz gives some very valuable notes upon the distinction of the genus *Cassidulus*, Lmk., and the genus *Rhynchopygus*,

d'Orb. He observes (Revision, p. 342) that Lamarck's genus contained two types, *C. lapis-canceri* and *C. caribbearum*, with *C. Marmini*, the former being retained to represent the typical Cassidulids, and the others being associated with the genus *Rhynchopygus* by Desor and Lütken. He places, however, this last-mentioned genus as a subgenus. I consider that this is the correct view, and therefore the most beautiful and elaborate drawings of *C. caribbearum* and other forms given by Lovén, in his *Études*, figs. 61-67 & 130, 179, relate to the subgenus. Desor relied too much upon the taxonomic value of one of the structures of *Cassidulus*, viz. the cribriform or smooth tubercleless median actinal band, which has been shown by Lovén to be unimportant, as it may be seen in the subgenus as well as in the type; or it may not exist (see also A. Agassiz, Revision, pl. xv. fig. 3). The only distinction is the lateral extension of the overhanging periproct of *Rhynchopygus*.

Genus CASSIDULUS, Lamarck, 1801, *Syst. Anim. sans Vert.* p. 348.

Agassiz & Desor, 1847, *Cat. rais., Ann. Sci. Nat.* vii. p. 157.

Desor, 1858, *Synopsis*, p. 288. Lütken, 1863 (pub. 1864),

*Vid. Medd. f. Naturh. Foren. i Kjöbenhavn.* p. 126. A. Agassiz,

1872-74, *Revision*, p. 342.

Syn. *Trochalia*, Pomel, 1883 = *Asterobrissus*, De Loriol, 1888.

Test small, oblong, depressed, broadest posteriorly, longer than broad, broader than high, convex abactinally, flat actinally.

Apical system excentric in front or subcentral; four perforated basal plates; the madreporite passing back and separating the postero-lateral basals, but not the radial plates.

Ambulacra subsimilar, short, flush, subpetaloid, not closing; pores continued from the petaloid part to the floscelle, which is well developed. Tentacles both simple and branchial (heteropodous).

Peristome excentric in front, the bourrelets narrow and strong, the phyllodes in grooves. One peristomial plate to each inter-radium. Usually a median band behind the peristome where there are no tubercles, and where the test is either cribriform, pitted, or plain, or it may be absent. The periproct supramarginal, at the commencement of a groove, elongate longitudinally. Tubercles small and very close abactinally, large and distant actinally, except on the median area posteriorly.

*Fossil.* Cretaceous: Europe, Asia, N. Africa, W. Africa, and N. America. Eocene: Europe, Asia, N. America.

Subgenus RHYNCHOPYGUS, *d'Orbigny*, 1855 (genus), *Pal. Franç., Terr. Crét.* vi. p. 324. *A. Agassiz*, 1872-4, *Revision*, pp. 342, 553.

Cassidulids having a test with a rostrum overhanging a transversely elongate supramarginal periproct.

*Fossil.* Cretaceous: Europe. Eocene: Europe, Africa, Asia. Late Tertiary: Guadeloupe, W. Indies.

*Recent.* Caribbean Sea, Panama, California, Galapagos.

Subgenus PYGORHYNCHUS, *Agassiz*, 1839, *Échin. foss. Suisse*, p. 53.

Syn. *Cyrtoma*, M'Clelland, 1840.

Test moderate in size, tumid abactinally, concave actinally. Petals long.

Peristome longest transversely, with a well-developed floscelle. Periproct supramarginal and transverse. A more or less bare median band in the posterior interradium actinally.

*Fossil.* Cretaceous: Europe, Asia. Eocene: Europe. Miocene: Europe, America, Australia.

Genus STIGMATOPYGUS, *d'Orbigny*, 1855, *Pal. Franç., Terr. Crét.* vi. p. 331. *Desor*, 1858, *Synopsis*, p. 296. *Stoliczka*, 1873, *Cret. Fauna S. India, Mem. Geol. Surv. Ind., Pal. Ind.* ser. viii. vol. iv. pt. 3, p. 27.

Test of moderate size, ovate in marginal outline, subhemispherical, flat actinally.

Apical system subcentral, with four basal plates, the madreporite in the largest, the right anterior; the basal plates perforated by genital ducts except the right anterior.

Ambulacra petaloid, narrow, moderate in length, none reaching the margin, unequal, narrowed distally, the anterior the longest.

Interradia finely granular actinally, with coarse mamillated tubercles most numerous at the floscelle, large and finely tuberculated abactinally.

Peristome slightly depressed, large, subpentagonal; floscelle greatly developed, the bourrelets long and tumid, and projecting into the peristome, and the ambulacral lips angular, large, and projecting inwards, the phyllode being on either side of them.

The periproct is narrow bottle-shaped at the upper part, in a long, narrow, posterior groove, which is shallowest and broadest just above a tongue-shaped slope at the margin of the test; irregular minute grooves on the sides of the groove. Spines small, closely, longitudinally striated.

*Fossil.* Cretaceous: Europe, Asia (S. Hindustan), W. Africa.

Genus ECHINANTHUS, Breynius, 1732, *Sched. de Echinis*, p. 53 (pars). Desor, *Synopsis*, 1858, p. 291. (See p. 149 of this Revision.)

Syn. *Parapygus*, Pomel, 1883.

Test moderate and small, thin, ovoid and broadest posteriorly at the tumid undulating margin, low, convex above, concave actinally.

Apical system with four perforated basal plates; madreporite small, slightly excentric in front, but separating the postero-lateral basals and also the radials.

Ambulacra unequal, petaloid, varying in the amount of closure, usually short, but may be long, continued simply over the margin, and developing into phyllodes at the peristome; the poriferous zones may be unequal. Interradia well developed.

Peristome excentric in front, less so than the apical system; a pentagonal floscelle well developed, and the bourrelets especially. Periproct oval, marginal or supramarginal, placed at the top of a more or less developed groove. Ornamentation of very small tubercles and granules, close, largest actinally.

*Fossil.* Cretaceous: Europe. Eocene: Europe, Asia, Africa (Egypt).

*Echinanthus Mortonii*, Mich. sp., is the *Hardouinia Mortoni* of Haime; I agree with Desor (*Synopsis*, p. 295) in not recognizing Haime's genus; but I consider it is a good subgenus.

Subgenus HARDOUINIA, J. Haime, 1853, *d'Archiac & Haime, Anim. foss. de l'Inde*, p. 214.

Test conical, as broad as long. Petals broad, pointed, reaching rather more than halfway to the margin.

Peristome nearly central, with a very well-developed floscelle. Periproct large, midway between the margin and the summit, in a groove.

*Fossil.* Eocene: Europe. Tertiary: Mississippi, U.S. America.

Genus EURHODIA, *d'Archiac & Haime*, 1853, *Anim. foss. de l'Inde*, p. 214; *Duncan & Sladen*, 1881, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, p. 69.

The test is large, stout, elongate, oval, truncated posteriorly, broad in front, depressed, slightly rounded abactinally, slightly concave actinally, and tumid at the ambitus.

Apical system small, excentric in front; four perforated basal plates; madreporite central.

Ambulacra forming a small abactinal rosette, they are small, unequal, the anterior not petaloid, and more open than the others; pores of pairs unequal.

Peristome large, excentric in front, elongate longitudinally, pentagonal; floscelle highly developed, especially the bourrelets, a pitted median actinal surface. Periproct elongated transversely, supramarginal, in a shallow basal groove, which becomes shallow posteriorly, and is surmounted by a rounded roof.

*Fossil.* Eocene: Asia (W. Sind).

Genus PARALAMPAS, *Duncan & Sladen*, 1882, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, p. 72.

Test small, high, even hemispherical, longer than broad, tumid above, especially posteriorly, the margin tumid, suboval, and may be overhung by the wider test above; the posterior part of the test precipitous and with a rostrum high up and overhanging the periproct; actinal surface concave.

Apical system slightly excentric in front; four perforated basal plates; the madreporite in the right anterior and passing centrally, and separating the basals on either side.

Ambulacra petaloid, short, subequal, or the anterior the larger and longest and well developed; poriferous zones with oblique and circular pores. Interradia very narrow at the apical system.

Peristome pentagonal, more or less excentric in front, slightly wider than long; floscelle well developed, with wall-like bourrelets. Periproct suboval, elliptical, broad, placed high, supramarginal, with a defined groove below it.

Tubercles small, uniform, crowded, equidistant, sunken in scrobicules, most widely spaced actinally.

*Fossil.* Eocene: Asia (W. Sind).



Genus CATOPYGUS, *Agassiz*, 1836, *Prodr. d'une Monogr. des Radiaires*, p. 185; 1847, *Cat. Rais., Ann. Sci. Nat.* vol. vii. p. 157. *Cotteau & Triger*, 1839, *Ech. de la Sarthe*, p. 184. *Desor*, 1858, *Synopsis*, p. 282. *Laube*, 1869, *Sitzungsb. Akad. Wiss. Wien*, vol. lix. Bd. 1, p. 190. *Studer*, 1880, *Monatsb. d. k. preuss. Akad. zu Berlin*, p. 861. *A. Agassiz*, 1881, 'Challenger' Report, p. 123. *Duncan*, 1887, *Quart. Journ. Geol. Soc.* vol. xliii. p. 420.

Syn. *Oolopygus*, d'Orb.

Small and moderate-sized Urchins, often cylindroid, longer than broad, rather low, tumid in front, rather keeled on the hinder part of the abactinal surface, truncated vertically posteriorly, where the periproct is high up, usually at the end of a groove and below the end of the keel. Actinally the test is rather swollen. Peristome excentric in front, pentagonal, elongate longitudinally, with phyllodes and bourrelets.

Apical system excentric in front; four perforated basal plates, the fifth absent; madreporite large, separating the posterior basal plates; radial plates small.

Ambulacra narrow, subpetaloid, nearly flush, continuous, with a pair of round pores in each plate as far as the peristome. Pores unequal; the outer of a pair more or less elongate. Granulation very close.

*Fossil.* Cretaceous: England, Europe, Asia.

I consider that certain Tertiary forms as well as some recent species which have been associated with this well-marked genus should come within the subgenus *Studeria*.

A. Agassiz described and figured *Catopygus recens*, which was dredged by the 'Challenger' (Report on the 'Challenger' Echini, 1881, p. 123); and Studer described *C. Loveni* from the seas to the south of the Cape of Good Hope, in the description of the 'Gazelle' Echinoidea, 1880. Both depart from the Cretaceous type; and A. Agassiz notices the uniporous condition of the ambulacra below the petaloid part, as well as the elongate nature of the outer pores of the pairs within it.

Subgenus STUDERIA.

The test is the same as that of *Catopygus* in shape, peristome, and periproct; but the ambulacra have only one pore in each plate in a poriferous zone below the subpetaloid portions.

*Fossil.* Australian Tertiaries (*Studeria (Catopygus) elegans*, Laube, sp.).

*Recent.* Australian seas, south of Cape of Good Hope, East Indian Archipelago\*.

The Eocene representative of the Cretaceous *Catopygi* found in W. Sind is a very striking form, leading from the Cretaceous type to the recent forms classified under *Studeria*. The shape of the test, the small dorsal ambulacral rosette, the single series of extrapetalous pores, the character of the floscelle, and the low position of the periproct distinguish the species, and require the definition of a new and closely allied genus.

Genus NEOCATOPYGUS, *Duncan & Sladen*, 1882, *Pal. Ind.* ser. xiv.,  
*Foss. Ech. W. Sind*, p. 76.

Test of moderate size, tumid and high, subrotund marginally, greatest height excentric posteriorly. Abactinal area convex; sides tumid, high; actinal surface convex, posterior extremity subrostrate and prominent.

Apical system excentric slightly in front, small, compact; four basals, all perforated for the genital ducts; madreporite large in the right anterior basal, and extending so as to separate the other basals.

Ambulacra petaloid; petals short and subequal, open at the extremity; pores unequal; extrapetalous pores single. Floscelle well developed; phyllodes with an inner series of supplemental pores.

Peristome small, pentagonal, excentric in front, bourrelets forming an ornamented wall-like rim. Periproct small, subcircular or oval, low, supramarginal, placed at the extremity of the posterior rostration. Subanal area tumid and rostrated, faintly grooved.

Tubercles small, perforate and crenulate, sunken in deep scrobicules. Actinal ornamentation the coarsest.

*Fossil.* Eocene: Asia (W. Sind).

\* The genus *Oolopygus*, d'Orbigny, 1856, only differs from *Catopygus* in the unimportant matter of the pores of the pairs not having a groove between them. This defect has no physiological bearing; and indeed it is doubtful whether all the pairs of every specimen of a species of *Catopygus* are united by a groove. *Oolopygus* of the Upper Chalk is a synonym of *Catopygus*.

Genus PHYLLOBRISUS, Cotteau, 1857-58, *Éch. foss. de l'Yonne*, vol. ii. p. 81. *De Loriol*, 1861, *Anim. invert. de Mont Salève*, p. 165; 1873, *Éch. Helv., Terr. Crét.* p. 233, pls. xviii., xix. *Cotteau, Peron & Gauthier*, 1879, *Éch. Foss. de l'Algérie*, fasc. 5, p. 157.

Syn. *Anthobrissus*, Pomel.

Test of moderate size, oblong, subcircular and rounded rather high in front, subtruncated posteriorly, swollen above, and almost flat actinally. Summit subcentral.

Apical system compact, with four perforated basal plates and five perforated radial plates.

Ambulacra petaloid, with narrow poriferous zones; inner pores round; outer pores elongate; zones more or less open.

Peristome slightly excentric in front, flush, pentagonal or may be oblique, with phyllodes and bourrelets. Periproct on the posterior surface at the top of a groove, variable in height, with keeled edges; it becomes narrower, and diminishes at the posterior edge. Tubercles small, scrobiculate, homogeneous, large around the peristome.

*Fossil.* Lower Cretaceous: England, Europe, N. Africa. Jurassic: Europe.

Genus CLYPEUS, Klein, 1734, *Nat. Disp. Echin.* *Agassiz & Desor*, 1847, *Cat. Rais., Ann. d. Sci. Nat.* vol. vii. p. 156. *Desor*, 1858, *Synopsis*, p. 275. *Wright*, 1859, *Pal. Soc. Monogr., Brit. Foss. Ech. Ool. Form.* p. 360.

Test rather thick, large, circular or somewhat pentagonal in wavy marginal contour, more or less truncated behind, low, discoidal, or slightly tumid dorsally, nearly flat actinally.

Apical system small, excentric posteriorly, or rarely central, with four triangular perforated basal plates, and a large madreporite which occupies the centre of the system, separating the postero-lateral basals and touching the posterior pair of radial plates, which are separated by long, narrow, interradsial plates.

Ambulacra wide, petaloid, not closing abactinally, narrow at the ambitus and actinally. Poriferous zones widening rapidly dorsally, and becoming equal in width (or more) to the very equally wide interporiferous areas, then diminishing in width and becoming very narrow, until midway between the ambitus and the peristome, where the pairs are arranged in very oblique triplets forming a

rudimentary phyllode. Pairs of pores in the petaloid parts, with the inner pore small and circular, the outer elongate transversely and in a decided long groove; pairs close, in simple low broad plates, and the costæ granular.

Interradia with broad, bent, low plates, much higher than any of the ambulacral plates, with a very delicate small tuberculation, largest actinally; tubercles scrobiculate, with a low broad boss and small simple mamelon; intermediate granulation rough.

Peristome subcentral or excentric in front, pentagonal, with narrow tumid granular or minutely tuberculated bourrelets and narrow phyllodes in grooves. Periproct in a groove along the median line of the posterior interradium, supramarginal, high up; the length of the groove variable, or the opening may be almost flush with the rest of the test.

*Fossil.* Oolite: England, Europe.

Subgenus *CLYPEOPYGUS*, *d'Orbigny* (genus), 1856, *Pal. Franç., Echin. Terr. Crét.* vol. vi. p. 418. *Desor*, 1858, *Synopsis*, p. 273 (genus).

Clypei with the apical system excentric in front, and narrow poriferous zones.

*Fossil.* Oolite: England, Europe. Cretaceous: Europe.

Genus *PYGURUS*, *Agassiz*, 1839, *Éch. Foss. de la Suisse*, p. 68; 1847, *Cat. Rais. des Éch., Ann. d. Sci. Nat.* vol. vii. p. 161. *Cotteau & Triger*, 1859, *Éch. de la Sarthe*, p. 65, pl. xiii. *Desor*, 1858, *Synopsis*, p. 309. *De Loriol*, 1888, *Mém. Soc. d. Phys. et Hist. Nat. Genève*, vol. xxx. no. 2, p. 102.

Test large, discoid, angular or undulating in marginal contour or not, and may be emarginate; depressed, subconical, or rather tall and conical dorsally, enlarged and rostrated behind; ambulacra grooved actinally, and the surface otherwise flat or tumid there.

Apical system central or excentric in front, small, with four or five basal plates, disunited, four with ducts; madreporite extending from the right anterior to the centre of the system; radial plates five, small, between the basals, and reaching the madreporite.

Ambulacra flush dorsally, unequal, long, the lanceolate, open petaloid parts reaching far to the ambitus, and tend to, but do not close, continued as narrow lines of pairs of small pores over

the margin and then placed in the deep smooth grooves, expanding and doubling into large and highly-ornamented phyllodes at the peristome.

Peristome excentric in front, pentagonal, with a highly-developed floscelle. Periproct inframarginal, in a special area, close to the posterior edge of the test, pyriform or ovoid and longitudinal, transverse rarely. Ornamentation small, largest actinally, except in the grooves.

Interradia greatly reduced near the apical system, usually with an undulating surface.

*Fossil.* Oolite: England, Europe. Cretaceous: Europe, N. Africa, W. Africa, N. America?

Genus FAUJASIA, *d'Orbigny*, 1855, *Pal. Franç., Échin. Terr. Crét.* vol. vi. p. 314. *Desor*, 1858, *Synopsis*, p. 316.

Test of moderate size, circular or oval in marginal outline, very convex or conical abactinally; summit slightly excentric in front, rounded or acuminate; subrostrated posteriorly.

Apical system upon the summit, with four perforated basals.

Ambulacra equal, similar, flush, petaloid, but open distally, very short; petals barely reaching halfway to the margin; inner pores circular, outer elongate. Actinal surface flat.

Peristome flush, subcentral, pentagonal, with a distinct floscelle. Periproct small, transverse, inframarginal. Ornamentation very small, largest actinally.

*Fossil.* Cretaceous: Europe and N. America.

Genus GALEROCLYPEUS, *Cotteau*, 1873, *Pal. Franç., Terr. Jura*, vol. ix. p. 360.

Test variable in size, subcircular in marginal outline, tumid and subconical dorsally, subrostrated posteriorly, and strongly pulvinate actinally.

Apical system at the summit, subcentral or slightly posterior, compact, the large madreporite irregularly produced centrally.

Ambulacra similar, narrow, widest at the ambitus, inner pores round, the outer slightly elongate as far as the ambitus, and then equal, round, oblique, and separated by a nodule. Tubercles small, wide apart, perforate, crenulate, and scrobiculate.

Peristome subpentagonal, sometimes oblique, slightly excentric in front, in a deep depression; interradial margins produced and

the ambulacral edges sunken, with a rudimentary floscelle. Periproct on the upper surface, in a groove commencing far from the apical system,

*Fossil.* Oolite: Europe.

Genus PSEUDODESOBELLA, *Étallon*, 1858-9, *Etud. Pal. Haut. Jura*, pt. 2, p. 15. *Desor & De Loriol*, 1868-72, *Éch. Helvet.* p. 303.

Test moderate, oval, broader than long, depressed.

Apical system small, subcentral, slightly posterior, compact, with four perforated basal plates and five perforated radial plates; the madreporite extending backwards and touching the united posterior radial plates.

Ambulacra slightly petaloid, open, the poriferous zone narrow, with the pairs above the tumid ambitus having an inner round and an outer and somewhat elongate series, flush, continued as round pores in pairs to the peristome. Tubercles numerous, distant, perforated and with scrobicules.

Peristome nearly central, pentagonal, rather elongate, with a moderate or absent floscelle. Periproct high up in a small short groove, which touches the posterior radial plates, and enlarges posteriorly.

*Fossil.* Oolite: England, Europe.

In the species of the genus *Echinolampas*, Gray, 1825, there is great variability of shape, size, and arrangement of the unequal poriferous zones; but I cannot see the propriety of receiving species into the genus which have equal poriferous zones. The genus is a very large and natural one if it is properly restricted.

Genus ECHINOLAMPAS, Gray, 1825, *Ann. Phil.* p. 7; 1855, *Cat. Ech. Brit. Mus.* pt. i. p. 34. *Desor*, 1858, *Synopsis*, p. 300. *A. Agassiz*, 1872-4, *Revision*, pp. 335, 551.

Test variable in size, more or less ovoid or circular at the tumid marginal outline; very variable in shape; moderate in height, tumid and vaulted above, very tall and conical or hemispherical, depressed and more or less discoid.

Apical system excentric in front, rarely subcentral, small, with four perforated basal plates; the madreporite large, in the right anterior basal, and extending into the centre of the system, and

separating the postero-lateral basal plates; the radial plates small, the posterior pair separated by the madreporite.

Ambulacra narrow or broad, petaloid to varying distances from the margin; the pores of a pair differing in shape, conjugate, the pairs separated by ornamented costæ; some poriferous zones unequal in length to their fellows, tending more or less to close or not. Beyond the petaloid parts the pores are in single series and small, until the peristome is reached, where they develop a feeble phyllode. Interambulacra large, with higher and fewer plates than the ambulacra.

Peristome slightly excentric in front, or subcentral, or central, pentagonal, with feeble bourrelets and phyllodes. Periproct elliptical, transverse, inframarginal, close to the posterior edge of the test. Tubercles of both areas very equal, small, very uniform, in sunken scrobicules, with miliaries. Spines small, short, forming tufts near the peristome.

*Fossil.* Eocene: Europe, Asia, Africa, W. Indies. Oligocene: Asia. Miocene: Asia, Australia, Europe, W. Indies.

*Recent.* Red Sea, Moluccas, East-Indian Islands, Australia, Cape of Good Hope, Senegal, Caribbean Sea.

#### Subgenus MILLETIA.

Peristome pentagonal, elongate longitudinally, barely sunken. Periproct irregularly circular in outline, close to the posterior edge, and somewhat oblique yet inframarginal.

Ambulacra broad, unequal, very open; poriferous zones nearly equal.

The type is *Echinolampas (Milletia) elegantulus*, Millet, 1854, Pal. de Maine-et-Loire, p. 178, redescribed by Cotteau, 1883, Bull. Soc. Zool. de France, vol. viii. p. 458, pl. xv. figs. 6-8.

*Fossil.* Europe?

In consequence of Zittel's discovery of the jaws of *Conoclypeus*, it became necessary for A. Agassiz to take his species *C. Sigsbei* out of that genus and to establish one which would include it. This led to the description of the genus *Conolampas*, A. Agass., 1883. De Loriol found that some forms which had been considered to belong to *Conoclypeus*, but which he showed had neither perignathic girdle nor jaws, had a decided phyllode at the peristomial margin of each ambulacrum. For these forms

De Loriol established the genus *Phylloclypeus* in Mém. Soc. de Phys. et d'Hist. Nat. de Genève, 1880, vol. xxvii. p. 79.

The question arises, What is the difference between *Conolampas*, Agass., and *Phylloclypeus*, De Loriol? I cannot see that there is much structural difference of physiological importance between them. The question is complicated by De Loriol's decision that *C. Sigsbei*, A. Agass., "est certainement un *Echinolampas*," Cat. Rais. des Éch. rec. à l'Île Maurice, Mém. Soc. Phys. et Hist. Nat. de Genève, vol. xxviii. p. 44 (1883). My study of the great series of *Echinolampas* in the Tertiaries of W. Sind clearly decides in my mind the classificatory importance of the unequal poriferous zones in the same ambulacrum; and I cannot admit in the typical genus *Echinolampas* forms with equal, long or short ambulacral zones. I demur, therefore, to the opinion of my friend, that *Conolampas* is an *Echinolampad*. I am content to believe that the two genera will come within the same alliance as *Palæolampas*, Bell, and *Microlampas*, Cotteau.

Genus PHYLLOCLYPEUS, *De Loriol*, 1880, *op. cit.* p. 79.

Syn.? *Clypeolampas*, Pomel, 1868, *vide* Pomel.

Test large, Conoclypeoid in shape and structure, except that there is neither a perignathic girdle nor jaws present. On the other hand, the floscelle is well developed and there are accessory plates in the phyllodes. Periproct oval, longitudinal, submarginal.

*Fossil.* Upper Cretaceous, *vide* Cotteau: Europe. Eocene: Europe, Africa, Asia.

Genus CONOLAMPAS, A. Agassiz, 1883, 'Blake' *Ech.*, *Mem. Mus.*

*Comp. Zoöl. Harv.* vol. x. no. 1, p. 48, and 1888, vol. xv. p. 99 (non *Conolampas*, Pomel, 1883).

Syn. *Conoclypeus*, A. Ag. (non auct.), 1878, *Bull. Mus. Comp. Zoöl.* no. 9, p. 190, pls. 1, 2.

Test large, taller than broad, hemispherical above the almost circular margin; flat actinally.

Apical system small, projecting at the centrally placed apex; button-shaped; four basal plates perforated; the madreporite in the right anterior basal, and extending into the centre of the system, and separating the basals; five radial plates, small, and the postero-lateral in contact with the madreporite and separated by it.



Ambulacra narrow, similar, equal, straight, flush, widely open to the ambitus, the parts of the poriferous zones with paired pores widening and then diminishing to a point; pores beyond terminating much before the margin of the test is reached, in single series; close to the peristome there is some doubling of pores and a small phyllode. Ambulacral plates numerous, low, broad primaries.

Interradia large, with much fewer and taller plates than the ambulacra. Tubercles of both areas similar, very small, perforate, crenulate, sunken in scrobicules, a miliary structure between the scrobicules.

Peristome small, central, pentagonal, wider than long; phylloides nearly crowded out by bourrelets. Perignathic girdle reduced to small knobs upon the interradia; jaws absent. Periproct inframarginal, small, elliptical, transverse, close to the posterior edge; with three large plates and some small ones. Spines short, slender, cylindrical, tapering.

*Recent.* Caribbean Sea, 76-460 fathoms.

The resemblance of the degraded perignathic girdle to that of *Echinoconus* is very suggestive.

Genus PLESIOLAMPAS, *Duncan & Sladen*, 1882, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, pp. 9, 54, pls. i., xiii.-xv. (*non* Plesiolampas, *Pomel*, 1883, *Thèses*, p. 62).

The test is moderate in size, variable in shape, ovoid, elongate, or polygonal, depressed, tumid at the margins and dorsum, concave around the actinally placed peristome.

Apical system excentric in front, with four basal plates, perforated and united; madreporite in the right anterior, and extending into the others centrally, large and separating the posterior lateral radial plates slightly.

Ambulacra subpetaloid, widely open at the distal extremity; poriferous zones subequal, almost straight; pores round, the outer sometimes elongate. Poriferous zones continued on the actinal surface as single pores; a rudimentary phyllode.

Interradia large and broad in comparison with the ambulacra; tubercles numerous, small, mamillated, imperforate, and non-crenulated, in deep scrobicules; miliaries numerous.

Peristome central, subcentral, or excentric in front, subpentagonal or oval-elliptical, transversely elongate, with a very

rudimentary floscelle. Periproct moderately large, inframarginal, elongate oval, placed longitudinally.

*Fossil.* Eocene: Asia (Sind). Probably *Palæopneustes conicus*, Dames, 1877, of the Vicentin Eocene, belongs here.

Subgenus *ORIOLOMPAS*, Munier-Chalmas, 1882 (genus), *Bull. Soc. Géol. de France*, sér. 3, vol. x. p. 386. *Cotteau* (genus), 1887, *Pal. Franç., Éch. irreg. Terr. Eocène*, p. 499.

*Plesiolampas* with crenulate and perforate tubercles.

*Fossil.* Eocene: Europe.

Genus *PALÆOLAMPAS*, J. Bell, 1880, *Proc. Zool. Soc.* p. 43.

Syn. *Clypeolampas*, Pomel\*.

Test moderate, thick, irregularly ovoid in tumid marginal outline, subconical and depressed dorsally, rather flat at the slightly precentral apex, slightly tumid actinally.

Apical system with four basal plates fused and the large madreporite central, four pores; radial plates small, and the pores variable in size.

Ambulacra rather broad, open, the pores remaining paired as far as the ambitus, the outer row of pores of each series of pairs continued over the ambitus to the peristome; a tendency to shortening of one of the paired poriferous zones only slightly indicated in the antero-lateral ambulacra. Ambulacra widest at the end of the double series of pores.

Interradia large, closely ornamented, and the interporiferous areas also with similar small primary tubercles.

\* M. Pomel does not give any references in his work, *Thèses*, 1883, p. 65, and in the instance of his genus *Clypeolampas* merely states:—" *Clypeolampas*, Pomel, 1868 (*Phylloclypeus*, De Loriol, 1880)." Search has been made in vain for any such genus published in 1868 by M. Pomel, and it is necessary therefore to take the diagnosis given in the page just mentioned. Careful study of this diagnosis proves that it will include many *Echinolampas*, *Conolampas* (Pomel, as well as the different genus of A. Agassiz), *Hypsoclypeus*, Pomel, *Plesiolampas*, Pomel (*non* Duncan and Sladen), and *Palæolampas*, Bell. Its author was not aware of its being an edentate genus, because that was made out for all forms with phyllodes by De Loriol, and therefore this insufficiently-defined genus does not include *Phylloclypeus*, De Loriol.

M. Cotteau has lately published *Clypeolampas Lesteli*, Cott. 1887, *Bull. Soc. Géol. de France*, sér. 3, vol. xv. p. 662. Humbert's drawings of it show that it is a *Palæolampas*, Bell, with larger primary tubercles in the abactinal plates. The genus cannot stand.

Peristome slightly excentric in front, small, pentagonal, broader than long, with bourrelets and phyllodes feebly but definitely developed. Periproct elongated transversely, submarginal.

*Fossil.* Upper Cretaceous: France. Tertiary: Europe\*.

Genus MICROLAMPAS, *Cotteau*, 1887, *Bull. Soc. Zool. de France*, p. 637, pl. x. figs. 10-13.

Test small, circular, tumid, subconical dorsally, flat, subpulvinate actinally.

Apical system central, the madreporite projecting centrally, with small radial plates.

Ambulacra becoming wider towards the ambitus, subpetaloid, open at their ambital extremity; poriferous zones composed of small unequal pores, appearing to be united by a groove, the outer pairs more elongate than the inner. At a considerable distance from the margin of the test the pairs cease, and a single row of pores is continued to the peristome.

Interradia more or less keeled close to the apex, the ornamentation similar to that of the ambulacra, not abundant, of small crenulate and perforate primary tubercles, largest at the ambitus and actinally.

Peristome deeply seated, pentagonal, with a slight floscelle. Periproct rounded in outline, flush, inframarginal.

*Fossil.* Eocene: Europe.

There is but one species, and it is small, but the affinities with *Palæolampas* and *Conolampas* are interesting.

Genus NEQLAMPAS, *A. Agassiz*, 1869, *Bull. Mus. Comp. Zoöl.* i. p. 271; 1872-4, *Revision of Echini*, p. 340. *Wyville Thomson*, 1874, *Phil. Trans.* vol. clxiv. p. 745.

Test small, thin, depressed, pyriform, arched above, truncated obliquely behind and rostrated, concave actinally.

Apical system in front of the highest point of the test, with four basal plates, three of which are perforated, and the madreporite is in the right anterior, and separating the basals 1 and 4 more or less.

\* M. Pomel, 1883, *Thèses*, p. 62, has mistaken the meaning of *Palæolampas*, which he considers to be a subgenus of *Echinolampas*. He places in it *Echinolampas Hellei*, Val.; but this recent form has ambulacra differing from those of *Palæolampas*, and it is a true *Echinolampas*.

Ambulacra flush, apetalous; poriferous zones uniporous; pores in small plates near the peristome and crowded there, producing rudimentary phyllodes between slight bourrelets.

Peristome beneath the apical system, and slightly in front of the centre, depressed, indistinctly pentagonal. Posterior inter-radium slightly ridged and sinking gradually to the depressed truncation, which is occupied by the large marginal periproct, which is oval and plated with scales; an anal tube may exist.

Interradial plates large. Tubercles small and numerous, largest actinally; many on the bourrelets. Spines straight, not long, slender, smallest with a tip of pointed tubercles. Pedicellariæ long and short, tridactyle, mostly blunt. Spheridia large, numerous, naked.

*Recent.* Mouth of English Channel, and Caribbean Sea, 230-600 fathoms.

### III. Family COLLYRITIDÆ.

Exocyclic nodostomes with apical systems disconnected and either elongate or subcompact. Ambulacra similar; bivium widely separated from the trivium; floscelle absent.

Genus *Collyrites*.

*Dysaster*.

*Hyboclypeus*.

*Infraclypeus*.

*Grasia*.

Genus COLLYRITES, *Des Moulins*, 1835, *Études s. les Echin.* p. 46. *Lovén*, 1874, *Études*, figs. 55-60, 98, 180.

Syn. *Dysaster*, Agass. (pars).

Test moderate and rather large, ovoid, oblong or cordiform in marginal outline, tumid, moderately high abactinally, depressed there or raised anteriorly, more or less narrowly truncated posteriorly, actinally flat, or irregularly swollen or concave.

Apical system elongate and dislocated; an anterior portion consisting of a small anterior radial plate and of the antero-lateral basal plates, separated from the posterior basal plates by the united antero-lateral radial plates; the posterior portion consisting only of the united postero-lateral radial plates. The portions are widely separated by numerous small plates belonging to the postero-lateral interradia; the madreporite in the right anterior basal plate.

Ambulacra disjunct and similar, the anterior in a slight groove or flush, the others flush, increasing in width to the ambitus, the pairs of pores in low primary plates; posterior ambulacra at varying distances from the anal groove. Interporiferous areas with small perforate and crenulate tubercles.

Interradia very unequal, broad; the postero-lateral areas uniting at the dorsum behind the postero-lateral basal plates.

Actinally the postero-lateral interradia are symmetrical, there being no fusion of plates. The interradial ornamentation is of the same kind as that of the ambulacra, but closer. Peristome pentagonal or subcircular, its margins formed by two unequal plates to each ambulacrum, and a single interradial plate to each area. Neither phylloides nor bourrelets. Periproct posterior, in a groove at varying heights above the margin.

*Fossil.* Oolite: England and Europe, N. Africa. Cretaceous: Europe.

Genus DYSASTER, *Agassiz*, 1839, *Éch. foss. d. l. Suisse*, vol. i. p. 1; 1847, *Ann. d. Sci. Nat.* vol. vii. p. 275 (Disaster). *Desor*, 1842, *Monogr. d'Éch. viv. et foss.* livr. 3, p. 7. *Cotteau*, 1885, *Éch. foss. de l'Yonne*, vol. i. p. 335; 1867-74, *Pal. Franç., Terr. Crét.* vol. ix. p. 106.

Test moderate, subcylindrical, long, low, rounded in front, truncated squarely posteriorly.

Apical system dislocated; the anterior part excentric in front, with the two pairs of basal plates in contact, the anterior and antero-lateral radial plates being external; the posterior part consisting of the postero-lateral radials united along the median line and separated from the anterior part by numerous small plates of the postero-lateral interradia; the madreporite in the right anterior basal plate, or extending between the postero-lateral basal plates.

Ambulacra disjunct, flush, increasing in width to the ambitus, the posterior may be flexuous; bivium and trivium widely separated; pairs in simple series. Postero-lateral interradia large, may have additional plates at the dorsum.

Peristome excentric in front, subpentagonal, plain; a single peristomial plate in each interradium. Periproct pyriform, in the posterior truncation, supramarginal.

*Fossil.* Europe, N. Africa.

This genus is distinguished from *Collyrites* by having the basal plates not separated by antero-lateral radial plates.

Genus HYBOCLYPEUS, *Agassiz*, 1839, *Éch. Suisse*, pt. i. p. 74.  
*Wright*, 1856, *Pal. Soc., Ech. Ool. Form.* p. 291, pls. xxi. & xxii.

Test moderate in size, ovoid, usually highest in front, gibbous, tumid, depressed, truncated and grooved posteriorly, swollen actinally.

Apical system subcentral, elongate; the antero-lateral radial plates uniting along the median line and separating the pairs of basal plates; a complementary plate or the fifth basal plate may separate the posterior basal plates; the anal groove separates the posterior radial plates.

Ambulacra disjunct, similar, flush, apetalous, the anterior sometimes in a groove and all more or less wavy. Poriferous zones narrow, and the pairs are in simple series, and close abactinally and at the margin, and wider apart and triserial at the peristome; plates low primaries abactinally, compound actinally.

Interradia wide, tumid, and the posterior with a long deep groove becoming wide and shallow at the truncated edge; periproct in the upper part.

Peristome excentric in front, deep, pentagonal, and longer than broad; no floscelle.

Tubercles close, uniform, small, perforate and crenulate; scrobicules sunken.

*Fossil.* England and Europe.

It is said that a compact apical system may occur, a complementary plate being between the pair of basal plates, and a similar plate is said to occur between the posterior pair of basal plates. It may be a matter of doubt whether the generic characters can vary so much.

Genus INFRACLYPEUS, *Gauthier*, 1875, *Cott., Peron & Gauthier, Éch. Foss. de l'Algérie*, 1876, fasc. ii. p. 23, pls. 14, 15.

Test large, more or less hemispherical, somewhat depressed, subcircular at the basal outline, slightly narrowest posteriorly, flat actinally.

Apical system subcentral, and at the highest point elongate; the antero-lateral radial plates uniting at the median line and separating the pairs of basals; posterior radials large, no fifth basal; the madreporite in the right anterior basal plate.

Ambulacra subequal, flush, apetaloid, similar, increasing in width to the margin, and thence diminishing towards the peristome. Pairs of pores in single series; pores small, oblique.

Anterior ambulacra straight, the antero-lateral wide apart and slightly curved. Actinally the ambulacra are in slight hollows of the test.

Interradia large, plates numerous, bent, low and broad.

Peristome in a slight concavity, oval, oblique, from right to left; without a floscelle or branchial incisions. Periproct inframarginal, elongate antero-posteriorly, ovoid or elliptical, in a groove, which is more or less continued abactinally. This groove seems occupied by small, elongate, distinct plates?

*Fossil.* Tithonian: Africa (Algiers).

The author considers that the genus is near *Pachyclypeus*, from which it differs in the position of the periproct and in the remarkable construction of the posterior groove. The obliquity of the peristome is in the opposite direction to that of *Amblypygus*.

Genus GRASIA, *Michelin*, 1854, *Rev. et Mag. Zool.* sér. 2, p. 439.

*Cotteau*, 1867-74, *Pal. Franç., Terr. Jura, Éch.* vol. ix. p. 34.

Test large, twice as long as broad, oval, depressed, tumid dorsally and actinally, truncated posteriorly.

Apical system very dislocated and elongate, the basal plates separated by the union of the antero-lateral radial plates, the postero-lateral radial plates placed far back.

Antero-lateral ambulacra far to the front, and the postero-lateral far behind, placed above the periproct; apetaloid, flush, the anterior straight and the others flexuous.

Peristome central, circular, plain. Periproct in a deep posterior groove which reaches the dorsum.

*Fossil.* Oolite: Europe.

There are some genera which link the Cassiduloidea and the Spatangoidea in a very interesting manner, and the character of the *dissimilarity of the construction of the anterior and the paired ambulacra is always evident*, but not so much as in the true Spatangoids.

#### IV. Family PLESIOSPATANGIDÆ.

Tests variable in shape and in the presence of small floscelles; ambulacra short or long in the subpetaloid parts; apical system compact or elongate and disjunct. Odd ambulacrum with pores differing in shape from those of the lateral ambulacra, or they may abort.

Genus *Eolampas*.*Archiucia*.*Claviaster*.*Asterostoma*.*Pseudasterostoma*.*Metaporhinus*.

Genus *EOLAMPAS*, *Duncan & Sladen*, 1882, *Foss. Echin. W. Sind* (*Pal. Ind.* ser. xiv.), pt. ii. p. 62, pl. xvii., and p. 150, pl. xxxi.; 1888, *Ann. & Mag. Nat. Hist.* ser. 6, vol. ii. p. 329.

Syn. *Petalaster*, *Cotteau*, 1884; *Pseudopygaulus*, *Coquand*, 1862, genus undes., only figured:

Test small, tumid, ovoid, subdepressed; the greatest height corresponding with the apical disk, and very excentric in front; the anterior slope rapid and precipitous, the posterior region subrostrate near the extremity.

Apical disk excentric in front, small; basals four, penetrated by genital ducts; madreporite central.

Ambulacra flush, small, short, petaloid, subequal; the odd anterior aborted. Poriferous zones of the other ambulacra subequal.

Peristome transversely oval, subcentral or very slightly excentric in front, with a perpendicular wall reaching upwards into the body-cavity. No bourrelets. Phyllodes very slightly developed. Buccal pores opening into the peristomial margin, with a small granule-like prominence over each, standing at the extreme edge of the peristomial ring. Periproct marginal, transversely oval. Tuberculation small, homogeneous, in sunken scrobicules; intermediate space subgranular and confluent.

The ambulacral rosette is small in relation to the size of the test, and the ambulacral petaloid ends terminate remotely from the margin of the test. The anterior ambulacrum has no double pores, and the grooves which are in their place do not present a single pore.

The interradial areas are largely developed abactinally. There is a faint groove in front of the sunken peristome. The periproct varies in its size and height in the posterior surface.

*Fossil*. Eocene of Asia (Sind); N. Africa (Algiers); Europe?

Genus *ARCHIACIA*, *Agassiz*, 1847, *Ann. d. Sci. Nat.* vol. vii. p. 101. *D'Orbig.* 1855, *Pal. Franç., Terr. Crét.* vol. vi. p. 283, pls. 909, 910. *Desor*, 1858, *Synopsis*, p. 324. *Cotteau*,



*Peron, & Gauthier, 1879, Éch. Foss. de l'Algér.* fasc. 5, p. 154, pls. x., xi. *De Loriol, 1888, Faune Crét. du Portug., Éch.* vol. ii. fasc. 2, p. 83, pl. xv.

Test moderate or large, thin, ovoid in marginal contour, broadest posteriorly, high, subconical at the anteriorly placed and overhanging apex, sloping gradually elsewhere, more or less grooved anteriorly. Actinally plane or convex.

Apical system at the highest point, with four perforated basal plates.

Ambulacra diverse, flush; the odd one non-petaloid, and with a biserial arrangement of small oblique pairs of pores in each poriferous zone; other ambulacra short, subpetaloid, tending to close, with diverse pores, the outer elongate; pores single (?) beyond the subpetaloid parts and in high plates, the others in low and broad primaries.

Interradia broad, and the plates broad, rather low, and numerous. Ornamentation of small tubercles and granules.

Peristome large and widely open, excentric in front, more or less pentagonal, and with a rudimentary floscelle. Periproct large, ovoid, elongate longitudinally, submarginal.

*Fossil.* Cretaceous: Europe, N. Africa.

GENUS CLAVIASTER, *d'Orbigny, 1855, Pal. Franç., Éch. Terr. Crét.* vol. vi. p. 281, pl. 909.

Syn. *Archiacia*, pars.

Test of moderate size, inordinately tall, finger-shaped. Apical system at the apex with four basal plates perforated.

Ambulacra very long, dissimilar, flush; the anterior with single pores in each zone, the other and paired ambulacra with slightly sunken pairs.

*Fossil.* Cretaceous: Asia.

The genus *Asterostoma* has given much trouble to MM. Cotteau and A. Agassiz. This may be seen by reading M. Cotteau's title of the genus in his Memoir in the Mém. Soc. Géol. de France, 1871-73, vol. ix. p. 177, and a passage in the Report on the 'Challenger' Echini, 1881, p. 167.

It must be admitted that A. Agassiz is quite justified in his remarks about the existence of more than one type in the genus *Asterostoma* as determined by M. Cotteau.

It is necessary to differ from M. Cotteau regarding the name

which should be placed after the genus, for there is no evidence that Lamarck wrote upon it. The genus first appeared in the Catal. rais., Ann. des Sci. Nat. vol. vii. p. 168 (1847). Agassiz there wrote:—"The genus links the Cassidulidæ and the Spatangoids; it has the shape of *Ananchites*, but differs from it in the mouth, which is median and pentagonal. The ambulacra are united together at the summit, and the odd one has the pairs of pores smaller and more distant than in the paired petals, almost like the Spatangoids. At the actinal surface the ambulacra correspond to broad and deep grooves. Anus posterior." The apex is evidently excentric in front. Agassiz defined the genus to include *Clypeaster excentricus*, Lam.

The next notice of the genus is in d'Orbigny's description of the Echinodermata, Pal. Franç., Terr. Crét. vol. vi. 1853-55, p. 279, pls. 906, 907, 908.

Genus ASTEROSTOMA, Agassiz, 1847, *Ann. d. Sci. Nat.* vol. vii. p. 168. Cotteau, 1871-73, *Mém. Soc. Géol. de France*, sér. 2, vol. ix. ii. p. 178.

The peristome is subpentagonal, not labiate, central or slightly in front. There are five actinal grooves from the peristome reaching the margin of the test, corresponding with the ambulacra. Anus posterior, marginal.

Ambulacra broad, subpetaloid, unequal; odd ambulacrum flush, with very small pores, circular and in simple series in regular pairs. Paired ambulacra flush, long, not contracting near the ambitus; pores simple, large, equal. Tubercles distant, scarce.

*Fossil.* Cretaceous?: Cuba.

The species is *Asterostoma excentricum*, Lam. sp., a very large form, 103 millim. long. It will be observed that the test is oval, longer than broad, broadest in front and slightly narrows behind; convex above, rounded in front, less so behind, tumid at the ambitus, flat actinally, with five grooves; ambulacra above the ambitus subpetaloid. In the plate 906. fig. 1 there is no anterior groove above the margin, and certainly the radial ends of the ambulacra are not sufficiently distant to enable any one to infer that the apical system was elongate. The species was probably *Echinolampas Kleinii*. There is no doubling of the pairs of pores at the peristome, and there is no sternum to the posterior interradius. On plate 908 the antero-lateral ambu-

lacræ are seen to contract above the ambitus so as to present curved poriferous zones, and the small pairs commence close to the margin. The postero-lateral ambulacræ do not contract, and are widest at the ambitus. All pores are circular.

These are perfectly recognizable definitions, and were reproduced to a certain extent by Desor, 1858, Synopsis, p. 196, pl. 37. The peristome is oval elliptical, and the small pairs of pores come regularly to its margins; but Desor makes the radial ends of the ambulacræ so distant that there is room for a suspicion that the basal plates were separated by the antero-lateral radial plates. This is because of incorrect drawing.

M. Cotteau noticed the genus anew in Bull. Soc. Géol. de France, sér. 2, vol. xxiv. p. 826; but the diagnosis relates to a distinct type, which is now named *Pseudasterostoma*. The diagnosis is therefore accepted for the new genus as follows:—

Genus PSEUDASTEROSTOMA, gen. nov.

Syn. *Asterostoma* (pars), Cotteau.

Test large, more or less elongate, sometimes subcircular, swollen above, almost flat below.

Apical system moderately developed, subcircular; four basal and five radial plates; the antero-lateral basal plates touch within; the postero-lateral and the posterior pair of radial plates are separated by a complementary imperforate plate (this is the small imperforate fifth basal plate).

Ambulacræ subpetaloid, unequal; the anterior different from the others in the structure of its pores. Poriferous zones of the paired ambulacræ of different shaped pores, largely open abactinally, reduced in size suddenly near the ambitus, the pairs there being microscopical and very distant; near the peristome the pairs become larger, closer, and more or less pronounced, and converge to the mouth. Tubercles scarce, small, crenulate, perforate, and scrobiculate; granules in circles around the scrobicules. Peristome sublabbiate, transverse, either central or very excentric in front; periproct rounded, flush, posterior, just above the margin.

*Fossil*. Cretaceous? : Cuba.

This generic definition does not notice the definite grooving of the actinal surface, the slightly contracting antero-lateral and the open postero-lateral ambulacræ above the ambitus, the comparatively central position of the simple peristome, and the general

simplicity of the ambulacra characteristic of *Asterostoma*, Agass.

The terminology appears to be:—

*Asterostoma excentricum*, Lmk., sp.

„ *cubense*, Cott.

*Pseudasterostoma Jimenoi*, Cott., sp.

Genus METAPORHINUS, *Michelin*, 1854, *Rev. et Mag. de Zool.* sér. 2, p. 439; *Bull. Soc. Géol. de France*, sér. 2, t. i. p. 270. *Desor*, 1858, *Synopsis*, p. 210. *Cotteau*, 1860, *Pal. Franç.*, *Terr. Jura*, vol. ix. pp. 28 & 504. *Cotteau, Peron & Gauthier*, 1876, *Éch. foss. de l'Algér.* fasc. 2, p. 17.

Test of moderate size and large, oval, slightly longer than broad, subcordiform, sometimes dilated at the ambitus. Very tall, gibbous, and projecting upwards anteriorly, and grooved and oblique behind, sloping at the sides, actinally tumid, especially behind the peristome. Anterior groove variable.

Apical system excentric in front, elongate, partly compact and disconnected and posterior. The four basal plates in contact and the posterior radial plates widely separated. The anterior radial plate may separate the antero-lateral basals.

Ambulacra, bivium disconnected from the trivium; diverse, apetaloid, flush, except the anterior, and this in a more or less defined groove, with simple, small, distant pairs of pores; paired ambulacra flexuous, pairs of pores becoming distant at the ambitus and numerous near the peristome; pores comma-shaped, placed obliquely to one another, or circular.

Postero-lateral interradia either uniting along the median line above or having plates intercalated there.

Peristome excentric in front, transversely elliptical-subundulate at its margin. Periproct supramarginal, either flush or in the upper part of a groove, and sometimes beneath an expansion of the test, oval or pyriform, acuminate above. Tubercles very small, crenulate and perforated, subscrobiculate; granules small, homogeneous, especially abactinally.

*Fossil.* Jurassic and Cretaceous: Europe. Tithonian: N. Africa.

VII.

The Suborder Spatangoidea and Families. Family Ananchytidæ and Genera, its Subfamily Urechininae and Genera. Family Spatangidæ and its divisions, the Adetes and Genera; the Prynadetes and Genera; the Prynnodesmia and Genera; the Apetala and Genera. Family Leskiidæ and Genus. Family Pourtalesiidæ and Genera.

II. Suborder Spatangoidea.

Exocyclic nodostomes, with the peristome excentric in front, rarely pentagonal in the adult, usually with a posterior labrum, behind which is a long plastron, either with a meridosternum or an amphisternum, bounded laterally by the posterior ambulacra. Periproct posterior, and either inframarginal, supra-marginal, or marginal. Apical system with four perforated basal plates, compact, or the madreporite may vary in its extension, or elongate. Ambulacra dissimilar. Tentacles heteropodous, either simple, branchial, or penicillate or disciferous. Interradia with a single peristomial plate; the postero-lateral areas usually unsymmetrical actinally. Spheridia numerous. Fascioles present or absent.

- I. Family ANANCHYTIDÆ.
- II. „ SPATANGIDÆ.
- III. „ LESKIIDÆ.
- IV. „ POURTALESIIDÆ.

I. Family ANANCHYTIDÆ.

Tests ovoid or subcordiform in marginal outline, tall or depressed; with or without an anterior groove; plates large. Apical system elongate or semi-disjunct; the madreporite in the right anterior basal plate, rarely diffused.

Ambulacra in a bivium and trivium, similar or slightly diverse, flush, apetalous; pairs of pores largest near the apex and at the peristome, may be uniporous.

Interradia all entering the peristome with a single plate, the postero-lateral unsymmetrical actinally, the posterior with a labrum and a long many-plated meridosternum, tuberculate and bounded by broad ambulacra.

Periproct either posterior, marginal, inframarginal, or supra-marginal.

Ornamentation small. Tentacles heteropodous. A marginal fasciole may exist.

Genus *Echinocorys*.

Subgenus *Jeronia*.

Genus *Holaster*.

Subgenus *Lampadaster*.

Genus *Offaster*.

*Hemipneustes*.

*Cardiaster*.

Subgenus *Infulaster*.

Genus *Hagenowia*.

Subfamily *Urechininæ*. Ambulacra uniporous.

Genus *Urechinus*.

*Cystechinus*.

*Calymne*.

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Incertæ sedis: *Enichaster*.

*Stenonia*.

Genus ECHINOCORYS, Breynius, 1732, *Sched. de Ech.* p. 58, pl. iii. fig. 2. *D'Orb.* 1853, *Pal. Franç., Terr. Crét.* vol. vi. p. 62. *Lovén*, 1874, *Études*, figs. 51-53, 97, 181.

Syn. *Ananchytes*, Lmk.; *Oolaster*, Laube, 1869.

Test large, thin, oval in marginal outline, flat actinally, straight or tumid at the sides above the sharp margin, high, rounded, or keeled apically.

Apical system elongate; usually the four basals are all perforated by genital ducts; but the foramen may be absent in the plate with the madreporite, or the right anterior basal plate; the antero-lateral radial plates large and united and separating the anterior and posterior pairs of basal plates.

Ambulacra nearly similar, all flush, apetalous, biporous, the plates low and narrow near the apex and gradually increasing in width and height to the margin, and small and dissimilar at the peristome; pairs of pores well developed abactinally; pores round or oval and nearly horizontal, becoming smaller, closer, and oblique towards the ambitus, where the pairs are more distant; at the peristome the adoral pore of a pair is in front of the aboral pore and separated by a nodule. Posterior ambulacra actinally long and broad, the pairs small and the pores oblique.

Interradia with large plates; the postero-lateral areas unsymmetrical actinally, from union of the second plates of both zones behind the peristomial plate of the right posterior area; all the

interradia enter the peristome with single plates, and that of the posterior is a labrum, behind which is a many-plated meridosternum forming a long plastron.

Peristome excentric in front, transversely oval; phyllodes moderately developed. Periproct inframarginal, posterior, oval.

Ornamentation of scanty small primary tubercles and numerous small granules; spines short and small.

*Fossil.* Upper Cretaceous: England, Europe, Africa.

Subgenus JERONIA, *Seunes*, 1888 (genus), *Bull. Soc. Géol. de France*, sér. 3, vol. xvi. p. 809.

Test large, subrostrate behind. Ambulacral plates broad and large. Apical system may have an accessory plate and only three genital pores. Some large tubercles near the ambitus.

*Fossil.* Cretaceous: Europe.

Genus HOLASTER, *Agassiz*, 1840, *Catal. Syst.* p. 1; 1847, *Ann. d. Sci. Nat.* sér. 3, vol. viii. p. 26. *Desor*, 1858, *Synopsis*, p. 336. *Pictet*, 1872, *Pal. Suisse, Éch. Crét.* p. 292. *Lovén*, 1874, *Études*, p. 49, pls. v. & xxv.

Syn. *Guettaria*, *Gauthier*, 1887; *Entomaster*, *Gauthier*, 1887.

Test variable in size, thin, ovoid in marginal outline, flat actinally, tumid and high, and may be keeled abactinally; a very broad and shallow groove anteriorly.

Apical system elongate; the madreporite in the right anterior basal plate.

Ambulacra apetalous, biporous, diverse; the anterior ambulacrum with pairs of small, oblique, circular or slightly elongate pores in the groove; the antero-lateral ambulacra the most divergent, their pores oblique, diverse, circular and linear, rather long; the pairs of the anterior and posterior zones may differ in size; the postero-lateral similar to the antero-lateral abactinally, like them also in having minute wide-apart pairs at the ambitus, but differing in being long and broad on the sides of the actinal plastron.

Interradia with large plates; the postero-lateral area of the right side actinally has the second plates of both zones beyond the single peristomial plate united, and is thus unlike the corresponding area of the left side; the peristomial plate of the posterior interradium is broad and larger than the others, it forms a labrum and is succeeded by a long many-plated meridosternum, but the

second plate of this stretches across and occludes the fellow plate from the peristomial plate.

Peristome excentric in front, elliptical and broadest transversely. Periproct supramarginal, oval.

Ornamentation of small primary tubercles raised above the general surface; granules exist in numbers and limit the plain scrobicules.

*Fossil.* Cretaceous: England, Europe, Asia, W. Africa. Miocene: Australia.

It is hardly possible for *Holaster Campicheanus*, d'Orb., to remain in the genus, and *H. Indicus*, Forbes, may be a *Cardiaster*.

Subgenus LAMPADASTER, Cotteau, 1889 (genus), *Bull. Soc. Zool. de France*, vol. xiv. p. 88.

Appears to be an *Holaster* with a pronounced ambulacral groove at the ambitus anteriorly, with large, distant, broadly scrobiculate tubercles especially abundant dorsally; the periproct below a posterior rostration.

*Fossil.* Cretaceous: Madagascar.

GENUS OFFASTER, Desor, 1858, *Synopsis*, p. 333. *De Loriol*, *Éch. des Env. de Camerino*, 1882, p. 10. *Lovén*, 1883, *Pourtalesia*, p. 92. *Gauthier*, 1887, *Bull. Soc. d. Sci. de l'Yonne*, vol. xli. e (pub. 1888), p. 403.

Test small, tumid, globose or conical or cordiform, flat or tumid actinally.

Apical system elongate; the madreporite in the right anterior basal plate. A doubtful or absent anterior groove.

Ambulacra flush, apetalous, with few high plates with minute circular pores in pairs, which diminish in size and increase in distance towards the ambitus, and are larger at the peristome.

Interradial plates high, larger than those of the ambulacra; the postero-lateral areas unsymmetrical actinally on account of the fusion of the second plates of the right posterior area; a narrow posterior peristomial plate with a small labrum, and posteriorly is a long meridosternum.

Peristome excentric in front, broader than long, oval. Periproct circular or ovoid, supramarginal. A marginal fasciole may occur.

*Fossil.* Cretaceous: England and Europe.

Certainly no forms with compact apical systems can enter.



Genus HEMIPNEUSTES, *Agassiz*, 1840, *Cat. Syst.* p. 2; 1847, *Ann. d. Sci. Nat.* vol. viii. p. 31. *Desor*, 1858, *Synopsis*, p. 348. *Lovén*, 1833, *Pourtalesia*, pp. 70, 92, 95.

Test large, ovoid in marginal outline, high and tumid, and raised or not in front abactinally, flat actinally; narrowly and deeply grooved anteriorly and more or less emarginate posteriorly.

Apical system central, elongate; the antero-lateral radial plates large and uniting at the median line; the madreporite diffused.

Ambulacra dissimilar; the anterior in the groove, its plates and pairs of pores numerous and small, the rows of pores wide apart; the paired ambulacra flush, semipetaloid, more or less curved, open distally, with numerous plates; the pores of the pairs circular and elliptical and elongate.

Interradia actinally symmetrical on account of the fusion of the second plates of both of the postero-lateral areas. Posterior interradium with a wide produced labrum and a meridosternous plastron with large plates and a zigzag of sutures.

Peristome excentric in front, much sunken, crescent-shaped, broad. Periproct supramarginal. A small equal granulation, large on the edge of the anterior groove.

*Fossil.* Cretaceous: Europe, Africa.

Genus CARDIASTER, *Forbes*, 1852, *Mem. Geol. Survey*, Decade iv. pl. ix. *Desor*, 1858, *Synopsis*, p. 344.

Syn. *Stegaster*, Pomel (pars); *Cibaster*, Pomel (pars).

Test large, cordiform, slightly convex actinally, tumid at the margin and rather depressed abactinally, broader than high, may be high anteriorly; with a well-marked anterior groove keeled at its sides, reflected more or less on the dorsum.

Apical system subcentral or excentric in front, elongate, the anterior basals being separated from the postero-lateral by the united antero-lateral radials. Madreporite in the antero-lateral basal plate.

Ambulacra apetalous and biporous, flush with the surface of the test except the anterior, which is in the anterior groove. Anterior ambulacrum with small pores, the pairs becoming wider apart vertically and horizontally, from increased dimensions of the plates, and reaching far down the groove, before they become smaller. The posterior poriferous zones of the other ambulacra have larger pairs of pores than their anterior zones; pores elongate, and often placed obliquely in the pairs.

Interradia with large plates, the plates behind the peristome forming a meridosternum.

Peristome excentric in front, and its orifice with a posterior lip looking forwards, elliptical, transverse. Periproct in a depression in the truncated posterior face, oval. A more or less complete marginal fasciole passing below the periproct.

*Fossil.* Lower Greensand to White Chalk: England, Europe, Asia, America.

Such forms of *Cardiaster* as *C. fossarius*, Benett, sp., from the Upper Greensand, *C. Cotteauana*, d'Orb., besides a variety of the first-named species, lead so decidedly up to *Infulaster*, Hagenow and Desor, that after due consideration I agree with Forbes in placing the species which were admitted by Hagenow, d'Orbigny, and Wright in that genus, with one exception, in the genus *Cardiaster*; or rather in a subgenus without a fasciole (*Infulaster*). I have examined the types described by Forbes, and they have no lateral or any kind of fasciole, and this was the opinion of the late Dr. Wright. All the characters of *Cardiaster* are present in the species *C. excentricus*, Forbes, and therefore the absence of the fasciole is not of generic importance. I do not consider that *Cardiaster rostratus*, Forbes (the *Infulaster rostratus* of Desor), belongs to the genus, and I admit it in a new one, *Hagenowia*.

Subgenus INFULASTER, *Hagenow* (genus), 1851; *Desor*, 1858, *Synopsis*, p. 347.

Test high in front, narrow; anterior groove deep and with strong lateral keels. Fasciole absent.

*Fossil.* Upper Chalk: England and Europe.

Genus HAGENOWIA, gen. nov.

Syn. *Cardiaster*, Forbes (pars); *Infulaster*, Desor (Hagen.) (pars); *Stegaster*, Pomel (pars).

Test small, long, narrow ovoid, low, with a long, slightly bent, blunt-pointed rostrum, grooved beneath and arising from the upper and anterior part of the test\*. The narrow dorsum of the test is saddle-shaped, short, and slopes from the rostrum to the oblique posterior truncation, which is narrowly grooved from below upwards. The anterior part of the test, beneath the

\* See Forbes, 1852, Mem. Geol. Survey, Decade iv. pl. x. fig. 7.

rostrum, is nearly vertical, narrow, and grooved. Actinally the test is narrower than dorsally, and is convex from before backwards and from side to side.

Apical system small, on the top of the rostrum; there are four basal plates \* placed closely, and the anterior pair are alone perforated by genital ducts. Radial plates small.

Ambulacra apetalous, and, with the exception of the anterior, which is in the anterior groove †, flush with the test. Pairs of pores of the anterior ambulacrum few and wide apart, continued up over the end of the rostrum abactinally. Pairs of the anterolateral ambulacra small and indistinct, passing down the rostrum abactinally ‡, and keeping close to the edge of the anterior part of the test; the postero-lateral pair passing parallel to the ridge of the dorsum to close to the oblique posterior edge, and then passing downwards to reach the actinal surface far back, and running along the convex median part on either side to the excentric in front peristome.

Peristome § at the end of the anterior groove, transversely elliptical; posterior interradius meridosternous behind the peristome. Periproct || at the top of the posterior groove.

Ornamentation small, scarce, made up of close miliaries. Primary tubercles absent. Fascioles absent.

*Fossil.* Upper Chalk: England, Europe.

HAGENOWIA ROSTRATUS, *Forbes*, sp., 1852, *Mem. Geol. Survey*, Decade iv. p. 3, pl. x.

Test compressed at the sides, with the apex produced as an elongate, oblique, slender rostrum.

### Subfamily *Urechininæ*.

Ambulacra uniporous.

The genus *Urechinus*, A. Agass., has had its solitary species well studied by its first describer, and also by Lovén; but it must be admitted that the shape and details of *U. Naresi* (*Naresianus*, A. Ag., is probably not classical, as "Nares" refers to a man and not to a place), given in the 'Challenger' Report, pls. xxix., xxx., xxx. a, are not those of the one species. Some forms have and others have not a subanal fasciole; and these last are,

\* Plate x. fig. 11.

† Figs. 8 and 9.

‡ Fig. 10.

§ Fig. 13.

|| Fig. 12.

14\*

moreover (as Lovén has pointed out), without the peculiar arrangement of the pores of the postero-lateral ambulacra in the subanal region, which is seen invariably with a true subanal fasciole.

It may be that there are two groups of forms, one without and the other with a subanal fasciole, and yet closely allied, as in the instance of *Micraster* and *Epiaster*; or the fasciole may be so small in the area which it surrounds, that it does not interfere with the ambulacra. The final solution of these questions must be left to the distinguished author of the Report on the 'Challenger' Echini; but for the present the latest authority, Prof. Lovén, must be consulted.

Genus URECHINUS, *A. Agassiz*, 1879, *Proc. Amer. Acad.* vol. xiv. p. 207; 1881, *Report on the 'Challenger' Echini*, p. 146, pls. xxix., xxx., xxx. a; 1883, *Report on the 'Blake' Echini*, p. 52, pl. xxvi. Lovén, 1883, *Pourtalesia*, p. 90, pl. xxi.

Test moderate in size, ovoid, tumid, tapering posteriorly in marginal outline, varying in height, either low, tumid, and feebly arched dorsally, or conical and taller than broad; convex actinally, with a slight keel over the region behind the peristome, truncated posteriorly, and with a hood overhanging the periproct; surface smooth.

Apical system nearly central, elongate, the lateral basal plates separated by the junction of the antero-lateral radial plates, with or without complementary plates; usually three genital pores; and the madreporite in the right anterior basal plate, but there may be a fourth pore; posterior basal plates united; radial plates irregular in shape.

Ambulacra all flush, apetalous, uniporous; the plates high, and differing little from those of the interradia, except those of the anterior, which are lower and more numerous; pores small.

Interradia with the postero-lateral areas broadest; actinally the single peristomial plates small and narrow, the labrum also and not prominent; the whole of the paired areas symmetrical; the second plates of both zones of each lateral interradium united so as to form a single plate beyond the peristomial plate; the third plates separate. The sternum semimerido-sternous (the plate 2 of zone *b* occupying the whole sternum, and followed by a small plate 2 of zone *a*, and at its side a plate 3 of zone *b*).

Peristome subcentral in front, slightly sunken, subpentagonal;

the ambulacra form the larger part of the margin; membrane with a central mouth surrounded by concentric buccal plates without tentacles, largest at the margin. Periproct low down in the posterior interradius, with a swelling below and more or less of a hood above, elliptical, its membrane with concentric plates. Below the periproct a mass of small miliary tubercles, which may simulate a fasciole. Tuberculation scanty, of primaries, with many secondary tubercles and miliaries; and hence a dense covering of very short spines, with broad bases.

*Recent.* 422 to 1800 fathoms, Pacific, south of equator, to Kerguelen, Magellan Strait, Caribbean Sea.

Genus *CYSTECHINUS*, *A. Agassiz*, 1879, *Proc. Amer. Acad.* vol. xiv.

p. 207; 1881, *Report on the 'Challenger' Echini*, p. 148.

*J. W. Gregory*, 1889, *Quart. Journ. Geol. Soc.* vol. xlv.

Test very large, thin to rather stout, may be flexible, ovoid or elliptical in tumid marginal outline, tall, subconical or subhemispherical, and then low; flat actinally, sunken slightly around the peristome, and tumid behind it.

Apical system subcentral or slightly posterior, elongate, plates confused; the pairs of basal plates separated either by large radial or by accessory plates; the basals large, irregular, and three, rarely four, perforated; a small madreporite in the right anterior basal; radial plates confused, some small.

Ambulacra similar, flush, apetalous, uniporous except close to the peristome, widening to the ambitus, with, as a rule, large plates, except close to the apex, where they are narrow.

Interradia with large plates tending to become hexagonal, very similar to ambulacral plates; a small peristomial plate to each area, and a meridosternum slightly tumid.

Peristome circular or subelliptical, transverse, in front of the centre, nearly flush, without lips, and with a raised internal ridge; peristomial membrane with concentric plates carrying small spines; mouth subcentral, in the membrane. Actinal tentacles tufted. Periproct elliptical, variably placed, marginal, and just above or below it; plates of membrane numerous.

But few primary tubercles on the plates, which may have ridges; many secondary tubercles and miliaries; spines short, very close and equal, some serrate and cylindrical, others club-shaped and spinulose. Pedicellariæ numerous, some on stalks, tridactyle, blunt or sharp-headed, mostly trefoil-like and sharp.

*Fossil.* Tertiary (late): Barbadoes.

*Recent.* Philippines; Tristan da Cunha to Buenos Ayres; Juan Fernandez to Chili; Antarctic Ocean, Marion Island to Kerguelen and Australia. Depth 1050 to 2225 fathoms.

Genus CALYMNE, *Wyv. Thomson*, 1877, *Voy. of the 'Challenger,'* "The Atlantic," vol. i. p. 397. *A. Agassiz*, 1881, *Report on 'Challenger' Echini*, p. 154. *Lovén*, 1883, *Pourtalesia*, p. 90. (*Arranged.*)

Test moderate, and probably large in size, and very thin, oval elliptical in marginal outline, longer than broad, and broader than high, rather flat actinally, with a low rounded keel extending from the peristome backwards, tumid above the slightly sharply-edged margin, rather flat abactinally. Plates numerous, large, very geometrical in shape.

Apical system with the bivium widely separated from the trivium by plates of the postero-lateral interrada; anterior basals perforated by the genital ducts which protrude; the madreporite is placed immediately behind the basals 2 and 3, and is probably in an intercalated plate. Behind the madreporite are two large plates, one on either side of the median line; and they appear to be imperforate basals; and behind these basals are four or five plates of the postero-lateral interrada. The anterior radial plate is in the usual place and is small; the antero-lateral radials are on the outer edge of the large basals behind the madreporite; and the posterior radials are close and behind the last of the intercalated interrada plates. The system is therefore elongate and disunited. Basal 5 is absent.

Ambulacra flush, apetelous, uniporous; plates large and high, differing but slightly in height from the interrada plates, the pore being far in the middle of the plates. The anterior ambulacrum resembling the others and, like them, flush with the test; the antero-lateral far forwards and on a line with the peristome; the postero-lateral far back abactinally, and with broad parts on either side of the sternum.

Interrada with the anterior pair much smaller than the postero-lateral, which are broad and which separate the bivium from the rest of the calyx abactinally; the antero- and postero-lateral interrada reach the peristome, with very narrow single plates. Posterior interradium narrower than the postero-lateral, actinally forming the low keel of the sternum, its first plate

at the peristome is small, and the next is larger and single, the arrangement being meridosternous; the plates are slightly produced backwards so as to form a slight beak-like structure which is placed below the periproct.

The peristome is far in front and is pentagonal; it has irregularly concentric rows of plates on its membrane. Periproct nearly circular in outline, largely plated, and placed above the keel-like margin of the posterior part of the test. A narrow marginal fasciole exists, and it dips below the edge anteriorly.

The ornamentation of the test is small and simple, the two or three small primaries, which are on each ambulacral and interradial plate abactinally, are irregularly placed, and there are some granules with them; there are larger tubercles which are rather crowded along the sternal keel, and also on the posterior part of the abactinal surface. In these places the spines are largest and paddle-shaped and striated; similar spines are also around the periproct. The tubercles elsewhere carry slender hair-like or blunt-ended and notched spines. Colour of the test pale green.

*Recent.* North of Bermuda, 2650 fathoms.

Genera incertæ sedis: *Enichaster*.

*Stenonia*.

Genus ENICHAETER, *De Loriol*, 1882, *Descr. des Échinides des Env. de Camerino, Mém. Soc. Phys. et Hist. Nat. de Genève*, t. xxviii. No. 3, p. 30.

The test is much longer than broad, oval-elliptical in marginal outline, without notches; slightly convex dorsally and actinally, moderate in size and greatly depressed.

The apical system is excentric in front, compact, and has four close, perforated basal plates. Madreporite surrounded by the basals, and very small.

Ambulacra flush with the test, showing no tendency to closing; the anterior has no groove, and is composed of very minute pores which are wide apart. The antero-lateral ambulacra are almost transverse, and the poriferous zones are equal; the pores are in simple pairs, round, and not united by a groove. The posterior ambulacra are the longest and closest.

The excentric-in-front peristome was probably pentagonal. The periproct opens quite at the summit of the posterior inter-

radium. The tubercles are well developed, wide apart, scrobiculate, and are over the whole surface of the test, and there are small close granules.

*Fossil.* Eocene (Oligocene): Europe.

Genus *STENONIA*, Desor, 1858, *Synopsis*, p. 333.

Large conical Urchins, with the periproct inframarginal, a bilabiate peristome, and with equal ambulacra. The apical system is compact. The ambulacral plates are about half of the height of the interradial plates.

*Fossil.* Upper Chalk: Europe.

There is but one species known of this remarkable genus, which Desor pointed out is *Echinocorys* (*Ananchytes*) with a compact apical system; he notices that the test is very thick, and that there is a bulging of the centres of the plates.

## II. Family SPATANGIDÆ.

Tests ovoid or cordiform, longer than broad, with numerous plates, and usually with an anterior groove.

Apical system with four or less perforated basal plates, compact, or with the madreporite variable in its posterior extension; radial plates five and external.

Ambulacra in a bivium and trivium, the anterior differing in shape and construction from the others, which may be petaloid dorsally or apetaloid, biporous, or uniporous; the postero-lateral long actinally and bounding the actinal plastron. Peripodia large around the peristome, forming rudimentary phyllodes, the tentacles being penicillate there, and either simple or branchial above.

Pairs of pores of the petaloid parts differing from the others.

Interradia narrow at the apex and at the peristome, where each has a single plate: the posterior plate the largest, and forming a labrum more or less projecting behind the transversely elliptical peristome. The postero-lateral interradia are usually unsymmetrical actinally, and the actinal plastron of the posterior area may be amphisternous or meridosternous.

Periproct in the posterior interradium. Fascioles present or absent. Spines slender. Spheridia most numerous in the bivium.

Unisexual or bisexual, undergoing free metamorphoses or not.



It has often been attempted to arrange the very numerous genera, both fossil and recent, of this Family into subfamilies, but with very doubtful success, on account of the presence of intermediate forms.

The researches of Lovén have indicated that the least artificial method of classification, and one which is comparatively natural, is to rely upon the subanal fasciole and its complementary modifications of the posterior ambulacra and their tentacles as a taxonomic character of importance, and to consider the other fascioles in a secondary sense.

- Division I. The *Adetes*. All fascioles absent.  
 II. The *Prymnadetes*. Subanal fasciole absent, other fascioles present.  
 III. The *Prymnodesmia*. Subanal fasciole present.  
 IV. The *Apetala*. Tests with flush, apetalous, usually uniporous ambulacra.

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I. Division *Adetes*.

Genus *Isaster*.

*Epiaster*.

Subgenus *Macraster*.

Genus *Echinospatagus*.

*Ennalaster*.

*Heterolampas*.

*Megalaster*.

*Hemipatagus*.

*Platybrissus*.

*Palæopneustes*.

GENUS ISASTER, Desor, 1858, *Synopsis*, p. 359. *De Loriol*, 1888, *Pal. de la Province d'Angola, W. Africa, Éch.* p. 118, pl. viii.

Test moderate in size, elongate, cordiform, largest in front, contracted posteriorly.

Apical system compact, slightly excentric in front.

Ambulacra slightly diverse, in shallow depressions, long, subequal; the anterior with smaller pores than the others, its pores elongate, forming a subpetaloid open area; the posterior ambulacra resembling the anterior pair, but less divergent, the pores

of the outer rows elongate, and those of the inner nearly circular ; petals not closed.

Interradia large, and the tubercles distant, small, and projecting, mamillate, perforate, and crenulated.

Peristome excentric in front, large, and with a posterior labrum. Periproct flush, broadly ovoid, acuminate above and below, supra-marginal. Fascioles absent.

*Fossil.* Cretaceous : Europe, W. Africa.

There is no doubt that the genus *Epiaster* contains species which belong to *Micraster*, the subanal fascioles of which are not visible, and some to *Hemiaster*. *Epiaster de Lorioli*, Wright, of the English Upper Greensand, when well preserved has a distinct peripetalous fasciole, and is a large, squat *Hemiaster*. This was known to Bone the artist ; but Dr. Wright could not see the fasciole, which is very apparent in the type specimen in the British Museum. Cotteau desired to unite the genus with *Micraster* ; but there are true species of *Epiaster* without a subanal fasciole, and without the invariably concomitant modifications produced by that fasciole, in the plates and pores of the posterior ambulacra, so well described by Lovén in his ' *Études*.'

Genus EPIASTER, *d'Orbigny*, 1853, *Pal. Franç., Terr. Crét. Éch.* vol. vi. p. 186.

Test moderate and large in size, cordiform in marginal outline, rather tumid and moderately high, or depressed and much broader than high, with an anterior groove, a rather narrow posterior truncation, and a tumid actinal surface posteriorly.

Apical system subcentral, with four perforated basal plates, and the madreporite usually separating the posterior basal plates, or it may be within the right anterior basal plate.

Ambulacra diverse, the anterior in the groove, with pairs of small pores on either side ; paired ambulacra petaloid dorsally, long, unequal, sunken, straight, divergent, tending to close or not ; pores elongate and unequal.

Interradia tumid dorsally.

Peristome transverse, excentric in front, the labrum projecting. Periproct oval, longitudinal, supra-marginal, placed in a definite area. Tubercles small, perforate and crenulate, with intervening miliaries, largest near the margin actinally and upon the sternum.

*Fossil.* Cretaceous : England, Europe, S. Hindostan, W. Africa.

Subgenus *MACRASTER*, *F. Roemer* (genus), 1888, *Neues Jahrb. f. Min. u. Geol.* Bd. i. p. 191, pl. vi.

Peristome without a projecting labrum.

*Fossil.* Cretaceous: Texas, N. America.

Breynius certainly placed several species belonging to very different genera in his *Echinospatagus*; but Agassiz in 1840 failed to produce a homogeneous group in *Toxaster*, which he considered to be a good genus and to supersede that of Breynius. Since the date of the Catal. Rais., some authors have followed Agassiz and others Breynius. At the present time it would be justifiable to reject both of the generic terms, but it is as well to give Breynius credit for recognizing a very interesting form before the days of Agassiz.

Genus *ECHINOSPATAGUS*, Breynius, 1732, *Schediasma de Ech.* p. 61, pl. v. figs. 3, 4 (pars). Lovén, 1874, *Études*, p. 58 1883, *Pourtalesia*, p. 92.

Syn. *Toxaster*, Agassiz, 1840 (pars); Desor, 1858, *Synopsis*, p. 350; De Loriol, 1888 (*Toxaster*), *Faune Crét. du Portug.*, Éch. ii. fasc. 2, p. 92. *Miotoxaster*, Pomel.

Test of moderate size, thin, broadly ovoid or subcordate in tumid marginal outline, broadest anteriorly, depressed, swollen dorsally and highest posteriorly, with an anterior shallow, broad groove and a posterior truncation.

Apical system excentric posteriorly, rarely central, with four perforated basal plates; the madreporite in the right anterior basal plate, and extending sometimes centrally, but not separating the posterior radial plates.

Ambulacra diverse, the anterior in the groove; the pairs of pores close vertically, and the pores unequal, those of the outer row the longest. Paired ambulacra unequal, subpetaloid, open, flexuous, very slightly sunken or flush, with unequal poriferous zones, and the pores of pairs unequal, the outer elongate and longer than the inner pores; pairs varying in width, and narrowing towards the end of the petals. Anterior paired ambulacra divergent but directed forwards; the anterior poriferous zones with smaller pairs of pores than the posterior zones. The postero-lateral ambulacra shorter than the others,

open, and the pairs of pores of the anterior zones smaller than those of the posterior.

Interradia tumid, the right posterior interradium actinally with normal heteronomy, the plates 2 and 3 of zone *a* being united; a sternum not quite symmetrical, but still amphisternous, and no true episternum.

Peristome excentric in front, subcircular or pentagonal, transverse; a small posterior labrum. Periproct in the posterior truncation. Tubercles distinct, small.

*Fossil.* Cretaceous: England, Europe, N. Africa, Asia (Syria).

De Loriol has proved the identity of *Ennalaster* and *Heteraster*.

Genus ENNALASTER, d'Orbigny, 1853, *Pal. Franç.* vi. *Terr. Crét. Éch.* p. 181. *De Loriol*, 1884, *Rec. Zool. Suisse*, i. no. 4, p. 622; 1888, *Faune Crét. du Portug.*, *Ech.* ii. fasc. 2, pp. 87-92, pls. xvi. & xvii.

Syn. *Heteraster*, d'Orb. 1853.

Test of small or moderate size, cordiform, low, tumid, slightly longer than broad, grooved in front, truncated behind.

Apical system compact, coinciding variably with the apex, may be excentric; four basal plates; the madreporite large, and separating or not the posterior basal plates.

The ambulacra diverse, the anterior broad in the slight anterior groove of the test, the broad pairs of pores close in vertical succession, numerous, a larger pair alternating with a small pair; the outer row of pores of the larger pairs elongate, and the inner smaller and shorter; intermediate small pairs either with elongate or circular outer pores, but always smaller than the others.

Petaloid parts of the antero-lateral ambulacra divergent, flexuous, tending to close, nearly flush, the poriferous zones unequal, the posterior the largest, anterior zone may be small; postero-lateral ambulacra short, divergent, zones unequal or not.

Peristome excentric in front, labiate, wide, arched in front. Periproct in the posterior truncation.

There are no fascioles.

*Fossil.* Cretaceous: England, Europe, N. Africa, Asia (Syria).

A careful comparison of the species of *Echinospatagus* and *Ennalaster* leaves great doubts in the mind whether the dif-

ferences in the pairs of pores of the odd ambulacrum—the essential distinction—are sufficient to separate the genera. De Loriol has expressed his doubts, but is content to permit the distinction to persist at present. It is not possible, however, to admit *Miotoxaster*, Pomel, although De Loriol names species with the title in his ‘Faune Crét. du Portug.’

The position of the next genus is doubtful, and it would at first sight not be considered a Spatangoid; but Humbert’s drawing shows some very definite characters.

GENUS HETEROLAMPAS, *Cotteau*, 1862, *Rev. et Mag. de Zool.* sér. 2, vol. xiv. p. 198, pl. ix.; *Cotteau, Peron & Gauthier*, 1881, *Éch. foss. de l’Algér.* fasc. 8, p. 151, pl. xv.

Test rather large, cordiform in marginal outline, truncated and narrow behind, tumid dorsally, longer than broad, highest posteriorly, depressed, flat actinally.

Apical system subcentral, large, with four largely perforated basal plates, the madreporite separating the posterior basal plates, and the antero-lateral radial plates intercalated between the basal plates; the posterior radials in contact and separating the posterior basals.

Ambulacra narrow, subpetaloid, slightly open, in grooves, subequal, similar; poriferous zones abactinally, with large elongate outer and smaller comma-shaped inner pores, placed transversely; beyond the petaloid parts the pairs are small and close to the peristome, one pore is much smaller than the other of a pair.

Peristome excentric in front, subpentagonal, longest transversely, widely open, without a floscelle; with a posterior labrum. Periproct oval, supramarginal. Tuberculation scanty.

*Fossil.* Cretaceous: N. Africa.

The genus is evidently closely allied both to Cassidulids and Spatangoids, and should be placed near *Echinospatagus*.

GENUS MEGALASTER, *Duncan*, 1877, *Quart. Journ. Geol. Soc.* xxxiii. p. 61.

Test large, elliptical in outline, with a deep anterior groove and small posterior truncation, depressed tumid abactinally, flat actinally.

Apical system excentric in front, small, with four genital pores. Ambulacra diverse, the anterior in the broad deep groove

aborted more or less ; the paired ambulacra with subequal petaloid parts, in deep, straight, or slightly flexuous grooves closed, the anterior pair more divergent than the posterior, not expanding but very equal in breadth.

Peristome very excentric in front and close to the notch, large, transverse, semilunar, and with a strong posterior labrum. Periproct large, elliptical, transverse, supramarginal, in the small truncation. Tuberculation very small. No fascioles.

*Fossil.* Miocene: Australia (see also Quart. Journ. Geol. Soc. 1887).

Genus HEMIPATAGUS, *Desor*, 1858, *Synopsis*, p. 416, pl. xliv. figs. 4-5. *Cotteau*, 1863, *Éch. foss. d. Pyrén.* p. 150.

Syn. *Tuberaster*, *Peron & Gauthier*.

Test small, cordiform, rather high, highest at the posterior truncation, as long as broad, tumid above, notched anteriorly, flattish actinally.

Apical system with four perforated basal plates ; the madreporite central and extending posteriorly, and separating the postero-lateral basal plates.

Ambulacra diverse, the anterior with small pores, and the lateral petaloid, long, and comparatively flush, with sunken poriferous zones. Several large perforate and crenulate primary tubercles, in deep scrobicules, wide apart, in the lateral interradia abactinally.

Peristome semilunar, with a projecting posterior labrum ; the amphisternum broad, smooth, and worn-looking. Periproct posterior, supramarginal. Fascioles absent.

*Fossil.* Eocene: Europe. Tertiary: Asia and Java. Pliocene: Europe.

Genus PLATYBRISUS, *Grube*, 1865, *Jahresb. d. Schles. Ges. f. Vaterl. Cult.* p. 61. *A. Agassiz*, 1873, *Revision*, p. 562.

Test moderate, depressed, elliptical, and somewhat rounded in the thick ambital outline, tumid dorsally, flat actinally.

Apical system excentric in front, small, with four perforated basal plates, compact.

Ambulacra diverse, flush, the anterior with very few pairs of small pores ; the lateral petaloid, but open at the ambitus, narrow ;

the pores close, and the outer row the largest; the postero-lateral continued over the margin actinally as very broad areas, which nearly join and pass forwards on either side of a very linear sternum; the antero-lateral with some doubling of pairs near the peristome.

Ornamentation of the interradia of secondary tubercles and miliaries, largest near the ambitus, and actinally there are larger tubercles, which are more distant, and also miliaries.

Peristome large, semicircular, excentric in front, slightly sunken, with a feeble labrum, so that the margins are on the same level. Posterior interradium actinally with an ill-developed narrow sternum, which becomes a small triangular surface behind the close ambulacral areas. Periproct pointed, elliptical, marginal. Fascioles absent.

*Recent.* Position unknown.

The genus *Palæopneustes*, A. Agassiz, is one of the most interesting of the series described by its distinguished founder; it gave him much trouble, and he has pointed out how strange are its superficial and positive alliances with Cretaceous, Tertiary, and recent types. The difficulty of grasping the true meaning of the genus has, in consequence of the association of *Lino-pneustes* with it as a subgenus, been increased, and it appears really straining a point to classify so closely forms with and without well-developed marginal and subanal fascioles. It is proposed to raise *Linopneustes* (p. 258) to the position of a genus.

GENUS PALÆOPNEUSTES, A. Agassiz, 1873, *Bull. Mus. Comp. Zool. Harv.* iii. no. 8, p. 188; 1874, *Hassler Exped. Ech., Mem. Mus. Comp. Zool. Harv.* no. viii. p. 13; 1883, *Report on the 'Blake' Ech., op. cit.* no. x. p. 60. (*Modified.*)

Test large, with a sharply defined or somewhat tumid ovoid ambitus, moderately high, subconical or subhemispherical abactinally, broadest anteriorly, broader than high; actinally flat, with a posterior oblique truncation.

Apical system slightly excentric in front, small, with four basal plates, three or all perforated, the right anterior containing part of the madreporite, which extends beyond, centrally, and separates the postero-lateral basal plates and also the posterior radial plates, and passes slightly into the posterior interradium.

Ambulacra diverse, flush, or nearly so, the anterior apetalous, with distant pairs of small round pores; paired ambulacra large, semipetaloid, open distally; outer pores of pairs elongate or comma-shaped, the inner round; beyond the petaloid portions, which are not very long, the pairs are continued as small round perforations in the large ambulacral plates to the peristome, where the plates become low and where fairly numerous pores are in peripodia; interporiferous areas with miliaries only, abactinally, with primary tubercles and miliaries actinally even over the postero-lateral ambulacra or not.

Interradia large, with primary tubercles scattered abactinally, and others, more or less numerous, on the plates remote from the sutures, crenulate and perforate, more numerous and crowded actinally.

Peristome excentric in front, large, semilunar, with a large projecting labrum; membrane plated. An amphisternum sloping on either side to the posterior ambulacra. Periproct supra-marginal, in the truncation, circular in outline, with numerous concentric plates. Spines variable, may be stout and long abactinally or small, always small actinally, and numerous and serrated, some spoon-shaped or broad at the top; within cellular. Abactinal tentacles branchial, those of the buccal region as pedicels with a globose top, and with long internal spicules. Fascioles absent, or a doubtful partial marginal.

*Fossil.* Eocene(?): Cuba.

*Recent.* Caribbean Sea.

The species described by Dames from the Eocene of the Vicentin is a *Plesiolampas*. See the similar ambulacra (p. 193).

M. Cotteau has described *Palæopneustes Antillarum*, 1875, from a probably Eocene formation in Cuba.

## II. Division *Prymnadetes*.

The prymnadete Spatangoidea have not a true subanal fasciole enclosing a plastron, nor are the plates of the posterior ambulacra modified as in the Prymnodesmia; yet a linear fasciole may pass beneath the periproct from a lateral or marginal or peripetalous fasciole in some genera: one or more of the latter fascioles present.

Genus *Hemiaster*.

Subgenus *Tripylus*.



Genus *Faorina*.

*Pericosmus*.

*Linthia*.

*Schizaster*.

*Prenaster*.

*Ornithaster*.

*Coraster*.

*Agassizia*.

*Moir*a.

Subgenus *Moiropsis*.

Genus *Hypsopatagus*.

The genus *Hemiaster*, Desor, has been greatly modified of late years, and some proposed new genera, which are characterized by peculiarities in the apical system alone, have been shown to be of no value (Ann. & Mag. Nat. Hist. ser. 6, 1888, vol. ii. p. 329). Desor took no notice of the apical system in his first definition, but unfortunately restricted the genus, subsequently, to the species which had an ethmophract system, the madreporite being in the right anterior basal plate. Lovén, A. Agassiz, and Gauthier have, however, explained the variability of the position of the madreporite and of the number of basal plates and genital pores. The classification adopted lately by M. Pomel, M. Munier-Chalmas, and by M. Cotteau is not consistent with the researches of zoologists.

The following is the first definition of the genus *Hemiaster* :—

Genus HEMIASTER, Desor, 1847, *Catal. Rais., Ann d. Sci. Nat.* sér. 3, vol. viii. p. 16, fig. in vol. vi. pl. 16. fig. 7.

Small swollen urchins; ambulacral summit posterior; ambulacra in broad shallow grooves, the posterior shorter than the anterior pairs. Peripetalous fasciole angular, encircling the ambulacral star; no subanal fasciole. Differs from *Micraster* in its more swollen shape and the fasciole.

Desor divided the genus :—1 type, Posterior ambulacra very short and barely half the length of the anterior petals. 2 type, Posterior ambulacra almost as long as the anterior, divergent, petals.

In Desor's Synopsis, 1858, p. 367, the following diagnosis occurs :—

“ Small, squat, short tests, swollen above and at the sides, truncated behind, a shallow anterior groove; apical system compact,

with four genital pores. Ambulacra petaloid, limited, concave, divergent. Peristome strongly bilabiate. A peripetalous fasciole."

This somewhat imperfect diagnosis would contain the Mesozoic species and some recent forms; but it excludes certain species of Cretaceous, Tertiary, and Recent ages, if too great a value is placed upon the position of the madreporite, the number of genital pores, and the existence or not of a lateral fasciole, which may be more or less transient.

It is necessary to revise the genus, and to consider the evidence afforded by recent discoveries. It is now beyond doubt that some species of *Hemiaster* are viviparous, or rather that the female receives the young which have not been freely swimming Plutei into her ambulacral petals; that during growth the periproct is at first above a fasciole, which environs the petaloid parts of the ambulacra, and that as the opening becomes lower down and more posterior, it crosses and often divides the fasciole. Thus badly limited lateral and infra-anal fascioles occur or not. During growth the depth of the petals, the position of the madreporite, and the number of genital pores varies. (See A. Agassiz, Report on 'Challenger' Echini, p. 179.)

In 1845 Philippi, in Wieg. Archiv, p. 344, pl. xi., diagnosed *Tripylus excavatus*, *T. cavernosus*, and *T. australis*, each with three genital pores only. He placed *Tripylus* as a subgenus of *Spatangus*. In 1851 Troschel, Wieg. Archiv, p. 72, wrote on the "genus" *Tripylus*, and defined it as follows:—Test cordate, suborbicular, convex; ambulacra deep, the anterior pair subtransverse; the dorsal pole subcentral. Genital pores three. A fasciole including the ambulacra.

Troschel divided his genus into:—

1. *Hamaxitus*—a line of fasciole passing under the periproct. The type was *Tripylus (Hamaxitus) excavatus*, Philippi.
2. *Atrapus*—the infra-anal fasciole incomplete. *Tripylus grandis*, Trosch.
3. *Abatus*—no infra-anal fasciole. Species *Abatus cavernosus* and *A. australis*.

In 1851 Gray (Ann. & Mag. Nat. Hist. ser. 2, vol. vii. p. 132) diagnosed *Faorina*, and included *F. chinensis*, *F. antarctica*, and *F. cavernosa*. The last two species belong to the subgenus *Tripylus* of Philippi. He also noticed *Tripylus* to be a genus which included a new species, *Tripylus Philippi*.

Gray in 1855, Cat. Rec. Ech. Brit. Mus. p. 58, without noticing

Troschel, defined *Tripylus* as *Hemiaster* with the ambulacra surrounded by a very flexuous fasciole, with a lateral fasciole separating from it and descending under the vent; ovarial pores three or four. He remarked that the genus differs from *Desoria* (*Linthia*) and *Schizaster* in the regular cordate form and central vertex. He again admitted *Tripylus Philippi*, Gray, in the group, but unfortunately this species is a true *Schizaster*, and also *T. excavatus*.

In 1873 A. Agassiz, Revision, p. 588, placed *Tripylus* as a subgenus of *Hemiaster*, noticed the peripetalous fasciole with continuous lateral and anal fascioles; and in the specific description of *T. excavatus*, the only recognized species, he mentions the three huge genital openings. The deep ambulacra were necessarily remarked upon.

The same author, however, removed the species placed in *Faorina* by Gray and in *Abatus* by Troschel, namely "*cavernosus*" and "*australis*," back again into *Hemiaster*, and observed that he could not find a trace of the subanal fasciole figured by Philippi.

In 'Les Études,' Lovén, 1874, pp. 13, 16, pl. xi. fig. 99, a drawing is given of the apical system of *Abatus Philippi*, Lovén, 1871 (*non* Gray, sp.), Öfversigt af K. Vet.-Akad. Förh. no. 8, p. 1070; and two genital pores are prominent features, their basal plates being separated by a long madreporite. On pl. xxix. are plans of the test of *Abatus Philippi* and of the buccal and anal plates; and although it is evident that Lovén considers *Abatus* to be a genus, the only distinction between it and *Hemiaster*, given, refers to the two genital pores and the backward projecting madreporite.

A. Agassiz had the advantage of seeing Lovén's type, and as during the voyage of the 'Hassler' many other specimens were obtained, the results of their examination were published in 1874 (A. Agassiz, Zool. Results of the 'Hassler' Expedition, p. 20, pl. iv. figs. 4-8). It was shown that the number of genital pores is variable, "as we find two or three quite indifferently; the posterior pair of genital openings is always present; if a third exists it is the right anterior one usually, but sometimes the left." A. Agassiz terms this form *Hemiaster*, and gives *Abatus* as a synonym. He places *Tripylus cavernosus* as a *Hemiaster*, and only recognizes *Tripylus excavatus*, Phil.

Mr. Edgar A. Smith (1879, Phil. Trans. Roy. Soc. clxviii. p. 271) placed under *Hemiaster* the *Abatus cavernosus*, and its synonyms (generic) *Brissus*, *Tripylus*, *Faorina*.

In the Report on the 'Challenger' Echini, 1881, p. 182, A. Agassiz united the species *Tripylus cavernosus* and *T. australis*, and absorbed them and *Abatus Philippi*, Lovén, in the genus *Hemiaster*; he noticed that in a full-grown specimen of the species "*cavernosus*" he could not find an anal fasciole. That was in accordance with Troschel, but in young specimens distinct anal fascioles joined to lateral ones existed, whilst in still larger tests the lateral fasciole had disappeared, the linear subanal remaining (p. 177).

The sex has much to do with the variation in structure of the apical system, and the number of pores is two or three; the female which was drawn (pl. xx a. fig. 19) had two genital pores only, the males have three.

In 'Pourtalesia,' 1883, p. 72, Lovén holds his ground with regard to the generic value of *Abatus*, and attributes it to Troschel. Certainly *Abatus* was a section of *Tripylus* according to Troschel. Lovén gives the synonymy of the species "*cavernosus*" and "*australis*," and it is interesting to observe that he is alone in the employment of the term *Abatus*. But although there may be a difference of opinion regarding the classification employed by the illustrious Professor, everybody must admire and be thankful for the anatomy given by him of the young "*cavernosus*," whatever its correct generic name may be, in which he indicates a fifth basal plate placed between the posterior radial plates and bearing the madreporite. Moreover, he has shown how homogeneous a group the ethmophract species of *Hemiaster* are, and that to introduce the others within the same category would violate the simplicity of the genus as established by Desor. But it must be conceded that Lovén's teaching infers evolution of the ethmolyesian from the ethmophract "*calyx*," and if the modern species of *Hemiaster* of the first group are the descendants of the ancient ethmophracts, surely it is a reason for preserving the genus with necessary modifications.

After what has been written, it appears necessary to absorb *Abatus* in *Tripylus* as a subgenus of *Hemiaster*. The attempt to divide the genus *Hemiaster* by grouping the species with four basal plates, each perforated, and having the madreporite separating the postero-lateral basals, under the genus *Trachyaster*, Pomel, will fail amongst the students of the recent fauna. The distinction is specific, and the so-called genus lapses. *Ditremaster* of M. Muvier-Chalmas (1885, Compt. Rend. Acad. Sci. 2 semestre,

p. 1076), quoted by M. Cotteau in Pal. Franç. (1887, Terr. Eocène, p. 411), is the same thing as *Abatus*, sensu Lovén, and is synonymous with *Tripylus* (see Duncan & Sladen, 1888, Ann. & Mag. Nat. Hist. ii. p. 333). The history of the species "*cavernosus*" should have been studied by the distinguished French Echinodermatists. *Ditremaster* is of no classificatory value. It appears to be reasonable, under the circumstances, to add to and alter slightly the Desorian diagnosis of *Hemiaster*, and to divide the genus into two types in reference to the position of the madreporite, the number of genital pores depending much upon the position of that upper end of the water-system. Finally *Tripylus*, with its persistent or evanescent latero-anal fasciole, may remain as a subgenus which will include *Abatus*, and it will come within the second division of the genus. I have found that Mr. Bone, who was Dr. Wright's artist, was correct in drawing a peripetalous fasciole in *Epiaster De Loriolii*, Wright. The species was placed in *Hemiaster* by Dr. S. P. Woodward; and therefore there is a large *Micraster*-like *Hemiaster* in the Upper Greensand with a delicate peripetalous fasciole, and this is the sole distinction from *Epiaster*.

Genus HEMIASTER, Desor, 1847, *Cat. Rais., Ann. d. Sci. Nat.* vol. viii. p. 16; 1858, *Synopsis*, p. 367. A. Agassiz, 1872-74, *Revision*, p. 585; 'Hassler' *Echini*, p. 20; 1881, 'Challenger' *Echini*, p. 177, pl. xx a. E. A. Smith, 1879, *Phil. Trans. Royal Soc.* vol. clxviii. p. 271. Lovén, *Études*, 1874, pls. xi. & xxix.; 1883, *Pourtalesia*, p. 72. Gauthier, 1887, *Assoc. Franç. Sci.* p. 406. Duncan & Sladen, 1888, *Ann. & Mag. Nat. Hist.* ser. 6, vol. ii. p. 329. De Loriol, 1888, *Faune Crét. du Portug., Éch.* vol. ii. fasc. 2, p. 98.

Syn. *Trachyaster*, Pomel; *Abatus* (sensu Lovén); *Leucaster*, Gauthier, 1887; *Perionaster*, Gauthier, 1887; *Ditremaster*, Munnier-Chalmas, 1885; *Opissaster*, Pomel (pars).

Test moderate and rarely large, cordiform in tumid marginal outline, with a more or less well-defined anterior groove, narrowest and truncated posteriorly, undulating or gibbose at the sides, short or longer than broad, highest subcentrally or posteriorly to the true centre, varying in height, tumid in the interradia dorsally, often keeled posteriorly to the vertex. Actinal surface swollen behind the peristome.

Apical system subcentral, with two to four basal plates, rarely

a fifth basal, two, three, or all perforated by ducts; the madreporite in the right anterior basal or extending centrally and more or less posteriorly, separating the postero-lateral basal plates and sometimes the posterior radial plates also.

Ambulacra diverse, the anterior in the groove; the pores oblique, in pairs on either side, plates numerous and low; antero-lateral ambulacra petaloid dorsally, sunken, more or less tending to close, diverging; the postero-lateral ambulacra with shorter petals than the antero-lateral or subequal, not so divergent; the pores of the petaloid parts of both of the ambulacra subequal, sometimes diverse, usually in narrow grooves, the outer pores usually the larger, elongate; actinally the posterior ambulacra are broad on either side of the tumid sternum, the pores beyond the petals distant but in pairs.

Interradia narrow at the apex and also at the peristome, with but few plates, many tumid; a small labrum anterior to an amphisternum; the episternum not developed; the plates below the periproct subequal. Normal heteronomy of right posterior interradium by union of the second and third plates of zone *a*.

Peristome excentric in front, transverse, open, semi-lunar, with a posterior labrum and often with raised antero-lateral edges. Periproct ovoid or elliptical, long vertically, high in the posterior truncation. Ornamentation small, a few primary tubercles perforate and crenulate, closest and largest actinally near the margin and on the sternum; miliaries abundant.

A peripetalous fasciole encircling the petaloid parts of the ambulacra, crossing the anterior groove and the keel behind the vertex, angular or subcircular, variable in its entry between the petals. Large disciferous tentacles within the fasciole on the anterior ambulacrum, others more or less branchial on the petals. Spines small, largest actinally and at the edges of the petals, which they may cover over. Depth of ambulacral petals variable according to age and sex, used as marsupia in the females.

Type I. *Ethmophracti*.—With four perforated basal plates, the madreporite in the right anterior basal plate, and not separating the other basal plates.

Type II. *Ethmolysii*.—Two or three, rarely four, basal plates with genital ducts; the madreporite passing centrally and posteriorly, separating the postero-lateral basal plates and in some the posterior radial plates also.

*Leucaster*, Gauthier, 1887, Bull. Soc. d. Sci. Hist. et Nat. de l'Yonne, vol. 41 e (pub. 1888), p. 386, is a *Hemiaster* with very small pores in the anterior zone of the antero-lateral ambulacra near the apex.

*Perionaster*, Gauthier, 1887, *ibid.* p. 389. The type is a very small immature *Hemiaster*, with a remarkably developed peripetalous fasciole, see *H. expergitus*, Lovén.

Type I.—*Fossil.* Cretaceous: England, Europe, N. Africa, Arabia, Hindostan, N. and S.; N. America?

*Recent.* E. Atlantic; W. of Spain; Caribbean Is., 464–485 fms.; Babia; Canaries, 620–750 fms.; Japan; Arafura Sea, 345–800 fms.

Type II.—*Fossil.* Tertiary: England, Europe, W. Indies, N. Africa, Egypt, Asia, Sind; Australia?; Java, N. America.

*Recent.* S. Hemisphere, Patagonia, Chili, Magellan, La Plata coast, Kerguelen, Heard Is., Staten Land, South Polar Seas.

Subgenus TRIPYLUS, *Philippi*, 1845; *Troschel*, 1851 (genus), division Hamaxitus, *Wiegmann Arch.* 1851, p. 72.

Syn. *Abatus*, Troschel.

Hemiasters with two genital pores in the female and three in the male, the apical system Ethmolysian, may have a fifth basal; peripetalous fasciole (around petaloid ambulacra deeply sunken in the female); a slender latero-anal fasciole, which may be incomplete. Type *T. excavatus*, Phil.

*Recent:* Patagonia and Chili.

Genus FAORINA, Gray, 1851, *Ann. & Mag. Nat. Hist.* vol. vii. p. 132; 1855, *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 56 (pars).

*A. Agassiz*, 1872–74, *Revision*, pp. 129, 607. *Lovén*, 1874, *Études*, pl. xxvii.

Test moderate in size, broadly cordiform in outline, grooved in front, narrower and truncated posteriorly, high and subconical. The vertex is central.

Apical system excentric in front, with four basal plates, two of which, or sometimes three, are perforated; madreporite projecting backwards.

Ambulacra dissimilar, the anterior in the groove with minute pairs of pores abactinally, and larger and more distinct actinally; the antero-lateral straight, sunken, divergent, open distally, the pairs of pores indistinct near the apex and elsewhere large and

regular; the zones are nearly parallel; interporiferous area smaller than the poriferous zones; the postero-lateral straight, sunken, open, shorter where petaloid than the antero-lateral and not so divergent, pores as in the other pair.

Peristome excentric in front, slightly semilunar, but narrow from before backwards and generally small; a broad posterior labrum. A narrow amphisternum, bounded by broad ambulacral areas. The convex actinal surface with small interradiial plates, the right posterior interradium with abnormal (or ancient) heteronomy, the second plates of zones *a* and *b* uniting. Periproct elliptical at the upper part of the posterior truncation.

A peripetalous fasciole following the general outline of the test, and the anterior part of it double and with or without offshoots. A very slender linear infra-anal fasciole extending from below the periproct to the ambitus near the ambulacra. Horizontal sutures often bare. Ambulacra bare on either side of a tuberculate sternum; tubercles uniform from the ambitus to the peripetalous fasciole, larger above it and adjoining the petals.

*Recent.* China. One species, *F. chinensis*, Gray.

The subanal branch is not sufficient to modify the posterior ambulacral plates, and does not bound a plastron.

Genus PERICOSMUS, *Agassiz*, 1847 (subgenus), *Catal. Rais.*, *Ann. d. Sci. Nat.* sér. 3, vol. viii. p. 19. *Herklots*, 1854, *Java Ech.* pt. 4, p. 16. *Desor*, 1858, *Synopsis*, p. 396. *McCoy*, 1882, *Prodr. Pal. Vict.* dec. vii. pp. 15-21, pls. 64-68. *Duncan*, 1887, *Quart. Journ. Geol. Soc.* vol. xliii. p. 423.

Test moderate to very large in size, thick, subcordiform, elongate or short, tumid and depressed dorsally, with a well-marked anterior groove, and more or less truncated posteriorly.

Apical system subcentral, compact and small; number of genital pores variable.

Ambulacra diverse, the anterior in the groove with small pairs of pores; the antero-lateral divergent, long, sunken, the posterior shorter and closer, pores unequal.

Periproct large, excentric in front, labiate. Periproct oval upon the posterior surface. Ornamentation small.

A peripetalous fasciole circumscribing the petaloid parts of the ambulacra, and a marginal fasciole passing all round the test, sometimes slightly disconnected.

*Fossil.* Upper Cretaceous (?). Eocene: Europe, N. Africa  
Java. Miocene: Australia.



M. Cotteau, *Éch. Foss. de l'Algérie*, 1885, fasc. 9, p. 68, mentions that M. Pomel considers that *P. Nicaisei*, Pom., has an apical system like *Micraster*, but that he finds three genital pores. He states that the greater number of species have only two genital pores. This is but one of the many proofs that the number of genital pores in a species is not a guide to its generic position.

Agassiz regarded *Pericosmus* as his third division of *Hemiaster*.

Genus LINTHIA, Merian, 1853, *Note sur les Éch.*, *Actes Soc. Helv.* p. 278. Desor, 1853, *Synopsis*, p. 395. A. Agassiz, 1872-74, *Revision*, pp. 138, 604; 1881, *Report on 'Challenger' Ech.* pp. 199, 204. Lovén, 1874, *Études*, pl. xxviii. E. A. Smith, 1878, *Ann. Mag. Nat. Hist.* ser. 5, vol. i. p. 67. Cotteau, 1887, *Bull. Soc. Zool. France*, vol. xii. p. 556.

Syn. *Desoria*, Gray, 1851; *Periaster*, d'Orb., 1854.

Test variable, small to large, oval or cordiform, grooved anteriorly, subacuminate or truncated posteriorly, tumid and gibbose dorsally, almost flat actinally.

Apical system small, excentric in front; four perforated basal plates; the madreporite separating the posterior basal plates and also the posterior radial plates.

Ambulacra diverse; the anterior in the broad groove, the pores round and small; the antero-lateral long, with the petaloid parts in grooves, moderately long, divergent, pairs of pores equal or subequal, nearly closing distally; postero-lateral ambulacral petals also in sunken grooves, less divergent and shorter than the others. Ambulacra forming the greater part of the peristomial margins, and moderately broad on either side of the sternum.

Peristome excentric in front, semilunar, with a well-developed posterior labrum. An amphisternum; the second plates of both of the zones of the right posterior ambulacrum united, so as to produce ancient heteronomy. Periproct at the upper part of the posterior truncation.

A peripetalous fasciole entering the interradia, a lateral fasciole starting from the peripetalous close to the antero-lateral ambulacra and passing beneath the periproct. Tubercles crowded, largest actinally, usually crenulate and perforate, and either on flat or in sunken scrobicules.

*Fossil.* Cretaceous: Europe, Africa, N. America. Tertiary: Europe, Africa, W. Sind, W. Indies.

The S. Hindostan Cretaceous species are now placed under *Hemiaster* by Stoliczka. *Periaster*, d'Orb., covers the same ground as *Linthia*; but see A. Agass., 1883, Report on 'Blake' Echini, p. 77.

*Recent*, as *Desoria*, Gray, 1851 & 1854, Cat. Rec. Ech. Brit. Mus. p. 58; and *Periaster*, A. Agass. sp., 1883, 'Blake' Echini, p. 77:—Australia, Tasmania, Pacific Islands (?); Arafura Sea, W. Indies.

Genus SCHIZASTER, *Agassiz*, 1847, *Catal. Rais., Ann. d. Sci. Nat.* vol. viii. sér. 3, p. 20. *Desor*, 1858, *Synopsis*, p. 389. *A. Agassiz*, 1872-4, *Revision*, pp. 363, 609; 1881, *Report on 'Challenger' Ech.* p. 199; 1883, 'Blake' *Ech.* p. 74. *Lovén*, 1874, *Études*, pl. xxxi.

Syn. *Opissaster*, Pomel (pars); *Periaster*, sensu A. Agass.

Test thin, small to large, tall to depressed, cordiform in tumid marginal outline, sloping up to the posteriorly excentric apical system; highest behind and truncated or acuminate posteriorly, may project there, slightly tumid actinally, with a broad and deep anterior groove, which marks the dorsum.

The apical system moderate in size, with two, three, or four basal plates perforated, and the madreporite extending centrally and posteriorly, and separating the posterior basal and radial plates.

Ambulacra diverse, the anterior in the groove and with close oblique pores in pairs, either in a single row on either side or confused and crowded: paired ambulacra petaloid, much sunken; the anterior flexuous, longest, only slightly divergent and extending forwards; the posterior smaller and closer, often very small; the poriferous zones broad and closing distally. The ambulacral areas on either side of the long sternum are narrow. The interradia are more or less gibbose and broad, and the second and third plates of zone *a* of the right posterior area are fused actinally.

Peristome excentric in front, semilunar, with a projecting posterior labrum and a large amphisternum. Periproct in the posterior truncation.

Ornamentation close and homogeneous, largest actinally and anteriorly. Spines short, slightly curved abactinally, and club-shaped at the end, larger and longer actinally, a tuft over the anal system, and two lateral tufts, rather close, at the end of

the actinal plastron. Fascioles: a peripetalous, and usually a lateral, which diverges from the former near the ends of the antero-lateral petals and passes beneath the periproct.

*Fossil.* Tertiary: England, Europe, India, Australia, West Indies, N. America, N. Africa.

*Recent.* N.E. Atlantic coast, Florida, West Indies, S. America, Cape of Good Hope, Mediterranean, Red Sea, Indian Islands, Japan, Philippines, China, Arafura Sea, Fiji, Marion and Kerguelen Islands (37-1507 fms.).

The synonymy of this genus is given by A. Agassiz in his 'Revision.' Unfortunately *S. gibberulus* has been placed in *Agassizia* by M. Cotteau, and subsequently in *Anisaster*, Pomel. Apparently the genus *Paraster*, Pomel, is a synonym.

GENUS PRENASTER, *Desor*, 1853, *Note sur les Éch., Act. de la Soc. Helv. d. Sci. Nat.* p. 279; 1858, *Synopsis*, p. 401. *Duncan & Sladen, Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, pt. ii. p. 90, pl. xix.

Test small or moderate in size, ovoid in marginal outline, rounded in front and truncated posteriorly, tumid and depressed dorsally, but rather boldly arched, convex behind the peristome actinally. There is no anterior groove.

Apical system very excentric in front, small, with four perforated basal plates, and the madreporite passing backwards and separating the posterior basal and radial plates.

Ambulacra diverse, the anterior flush, with pairs of small oblique pores; the paired ambulacra in very faint grooves, not closing, subpetaloid, almost straight; the anterior the longest and very divergent; some slight difference may exist between the dimensions of the anterior and posterior rows of pairs of pores in the antero-lateral ambulacra.

Peristome excentric in front, with a strong labrum. Periproct at the top of the posterior truncation.

Tubercles small to moderate, scrobiculate, perforate and crenulate, largest actinally.

A peripetalous fasciole wanting anteriorly, not extending beyond the point of junction with the marginal fasciole. A marginal fasciole surrounding the test, dipping down in front, and passing below the periproct behind.

*Fossil.* Eocene: Europe, Asia (W. Sind), N. Africa.

Genus ORNITHASTER, *Cotteau*, 1886, *Ech. nouv. ou peu connus*, *Bull. Soc. Zool. de France*, vol. xi. p. 710.

Test moderate in size, thick, slightly elongate, tumid above, broadest and rounded in front, subtruncated behind, highest near the posterior surface, broader than high. No anterior groove.

Apical system excentric in front, subcompact, with four close genital pores.

Ambulacra dissimilar, all flush, narrow, and enlarging slightly to the ambitus; the anterior without a groove, with simple pairs of pores arranged more or less obliquely. The paired ambulacra slightly subpetaloid, open; the inner pores circular and the outer comma-shaped; pairs close abactinally and distant at the ambitus. Interradial ornamentation of numerous small scrobiculate tubercles most frequent actinally and much granulation.

Peristome rather large, subcircular, superficial, slightly excentric in front, without a trace of labrum or phyllodes. Periproct circular, at the summit of the posterior truncation.

A peripetalous fasciole well developed, not sinuous, approaching the periproct, but anteriorly and superiorly, and crossing the ambulacra above the ambitus and sloping in front so as to be at a much lower level there than posteriorly.

*Fossil.* Eocene: Europe (Spain).

M. Cotteau places the genus near *Coraster*, Cotteau.

Genus CORASTER, *Cotteau*, 1886, *Bull. Soc. Zool. de France*, vol. xi. p. 708. *Seunes*, 1888, *Bull. Soc. Géol. de France*, sér. 3, vol. xvi. p. 801.

Test small, thick, circular in marginal outline, subtruncated posteriorly, regularly tumid and high dorsally. A very small anterior furrow.

Apical system subcompact, with four basal plates and each with a pore, and the madreporite not separating the postero-lateral plates.

Ambulacra dissimilar, flush, straight, narrow, enlarging with approach to the ambitus; the anterior with minute distant pairs of pores; the paired ambulacra with the inner row of pores circular, and the outer comma-shaped and oblique.

Tubercles abundant, small, scrobiculate, and with homogeneous miliaries.

Peristome very excentric in front, slightly sunken, subcircular, and with a posterior labrum which projects. Periproct circular, at the top of the posterior truncation.

Fasciole peripetalous, well developed, subcircular, sloping downwards and forwards, cutting across the ambulacra far above the ambitus, nearly circular but slightly angular in the postero-lateral interradia. Pores below the fasciole circular and similar.

*Fossil.* Upper Cretaceous or Eocene: Europe (Spain, France); Asia (Turkestan).

Genus AGASSIZIA, Valenciennes, 1846, *Voy. d. Venus*, pl. i. fig. 2. Agassiz, 1847, *Ann. d. Sci. Nat.* vol. viii. p. 20. Lütken, 1863 (pub. 1864), *Vid. Medd. f. Nat. For. i Kjöb.* p. 134. A. Agassiz, 1872-4, *Revision*, pp. 88, 353, 594; 1883, 'Blake' *Ech.* p. 71, pl. 25. Lovén, 1874, *Études*, pl. xxx. figs. 191-193; 1883, *Powrtalesia*, pl. x. fig. 93.

Test thin, ovoid, moderate in size, truncated posteriorly, tumid and subhemispherical dorsally, highest posteriorly, without an anterior groove, rather flat actinally, with a convex surface behind the peristome.

Apical system excentric or subcentral posteriorly, or not; small, with four close perforated basal plates. Madreporite in the right anterior basal.

Ambulacra diverse, the anterior in a very narrow depression; the pairs of pores small and distant, the tentacles with a sucker and penicillate; the antero-lateral ambulacra divergent, long, open, slightly curved, with the anterior row of pairs of pores absent; postero-lateral shorter than the antero-lateral, closer, and with both rows of pairs of pores developed. Plates 2 and 3 of zone *a* of the right posterior interradium fused.

Peristome very excentric in front, narrow, transverse, with a posterior labrum and a well-developed amphisternum; peristomial plates rather large near the anterior margin. Periproct elliptical, transverse, in the posterior truncation, its plates large near the edge.

A peripetalous fasciole entering the angles of the interradia, especially posteriorly. A lateral fasciole arising from the peripetalous close to the distal ends of the antero-lateral ambulacra and passing backwards to reach the posterior surface of the test below the periproct. The anterior part of the peripetalous fasciole dips down so as to be visible from the actinal surface.

Spines delicate, and those of the miliaries club-shaped. Ambulacral pedicellariæ small-headed, long-stemmed, articulated at the base. Tentacles, some of the anterior near the apical system

fimbriated like the buccal, others disciferous; within the petals the tentacles are broad, compressed, lobed, beyond simple; buccal tentacles pedicellate. Anal plates large, often less than eight, and projecting.

*Fossil.* Tertiary: N. America, West Indies.

*Recent.* Florida, Gulf-stream, Caribbean Islands, Peru, Panama, Gulf of California, 36-391 fms.

*Agassizia gibberula*, Cott., is a *lapsus calami*, it is a *Schizaster*.

Genus MOIRA, A. Agassiz, 1872, *Revision of the Echini*, p. 365.

Syn. *Moera*, Michelin, 1855; Lütken, 1863 (pub. 1864), Vid. Medd. f. Nat. For. i Kjöb. p. 123.

Test moderately high, thin, tumid abactinally and rounded from side to side actinally.

Apical system subcentral, with two of the basals perforated for genital ducts.

Ambulacra resemble narrow and deep slits starting from the summit; the anterior notches the front of the test and the groove is continued to the peristome. Coronal plates tumid, except near the sutures.

Peristome excentric in front, semilunar, and with a projecting posterior lip. Periproct on the truncated posterior surface.

A peripetalous fasciole clings to the very edges of the deep ambulacral grooves. A latero-anal fasciole. Tubercles small. The anterior ambulacrum is sometimes divided, and all the ambulacra form broad projections on the inside of the test.

*Fossil.* Miocene: Sind. Post-Pliocene: S. Carolina.

*Recent.* Red Sea, Zanzibar, West Indies to N. Carolina, California, 60 fms.

Subgenus MOIROPSIS, A. Agassiz, *Report 'Challenger' Echin.* p. 205, pl. xxxvi. figs. 4-7 (1881).

Test high, cordate, the high incurved posterior surface extending inferiorly into a backward, prominent and well-developed beak.

Anterior ambulacrum shorter than the antero-lateral and longer than the very short posterior ambulacra; all are petaloid. The anterior ambulacrum is the broadest and the postero-lateral are very small. The anterior ambulacrum has a petaloid end which is in the shallow anterior groove.

The peripetalous fasciole is small, and the latero-anal is well developed and passes from the peripetalous fasciole, about half-way down the antero-lateral petal, and crosses the side of the test

obliquely so as to pass over the posterior face at some distance below the top of the test and the periproct.

*Recent.* Indian Archipelago, 129 fms.

The subgeneric character is the shape and relative size of the anterior ambulacrum.

Genus *Hypsopatagus*, *Pomel*, 1883, *Thèses*, p. 31. (*Slightly enlarged.*)

Syn. *Macropneustes*, Agass. (pars).

Test moderate and large, tumid in ovoid outline, depressed and tumid dorsally, rostrated posteriorly and truncated.

Apical system subcentral, or slightly excentric in front.

Anterior ambulacrum in a slight groove; pores simple. Paired ambulacra either long and grooved, or shorter and broad and semi-flush; the poriferous zones slightly sunken, and the interporiferous areas ornamented and tumid.

Peristome excentric in front, semilunar, transverse. Periproct in the posterior truncation. A peripetalous fasciole including scarce or moderately close primary tubercles.

*Fossil.* Eocene: Europe and Africa and Asia. Miocene: N. Africa.

M. Pomel cites as the types *H. Meneghinii* and *H. Ammon*, and the Sindian species of *Macropneustes* become *Hypsopatagus speciosus*, Dunc. & Sladen, *H. rotundus*, Dunc. & Sladen.

### III. Division *Prymnodesmia*.

Spatangoidea with a subanal fasciole, and the plates of the postero-lateral ambulacra within the fasciole modified, and their pores also. Other fascioles may exist.

Genus *Micraster*.

Subgenus *Brissopneustes*.

Genus *Brissus*.

Subgenus *Meoma*.

Genus *Spatangomorpha*.

*Troschelia*.

*Metalia*.

*Rhinobrissus*.

*Brissopsis*.

Subgenus *Cyclaster*,

Genus *Brissopatagus*.

*Spatangus*.

Subgenus *Loncophorus*.

Genus *Maretia*.

*Eupatagus*.

Subgenus *Macropneustes*.

Genus *Nacospatangus*.

*Gualtieria*.

*Linopneustes*.

*Neopneustes*.

*Cionobrissus*.

*Echinocardium*.

*Breynia*.

*Lovenia*.

Genus MICRASTER, *Agassiz*, 1840, *Cat. Syst.* p. 2; 1847, *Cat. Rais., Ann. d. Sci. Nat.* sér. 3, vol. viii. p. 23. *Desor*, *Synopsis*, 1858, p. 360. *Lovén*, 1874, *Études*, pls. xi., xxxiii. *Duncan & Sladen*, 1884, *Foss. Ech. W. Sind*, pt. iii. p. 189, pl. xxxvii. (*Pal. Ind.* ser. xiv.). *Gauthier*, 1887, *Bull. Soc. d. Sci. Hist. et Nat. de l'Yonne*, vol. 41 e (pub. 1888), p. 367.

Test moderate or large, cordiform, narrowest and truncated posteriorly, tumid, rather depressed.

Apical system excentric in front, small, with four perforated basal plates, rarely with only three perforations; the madreporite either restricted to the right anterior basal, or passing beyond it and separating the postero-lateral basal plates. (The Tertiary species have only three genital perforations.)

Ambulacra diverse, sunken; the anterior apetaloid, with the small pairs of pores becoming distant towards the ambitus; the antero-lateral ambulacra subpetaloid dorsally, diverging, longer in the subpetaloid part than the postero-lateral; postero-lateral ambulacra forming a slight angle at the apex; pores of both areas elongate.

Interradia with large plates; actinally the right postero-lateral area has the second and third plates of zone *a* coalesced, the corresponding plates of the left postero-lateral (4) interradium being separate. A symmetrical amphisternum, but without an episternum; many plates between the sternum and the periproct, which is oval and high up in the truncated or grooved posterior face, and sometimes overhung by the end of the keel of the posterior interradium. Subanal fasciole broad; the sixth ambulacral plate and four others being altered in shape, and each having a pair of pores within the fasciole.



Peristome excentric in front, transversely elliptical, with a small posterior projecting labrum.

Ornamentation of very small raised perforate and crenulate tubercles abactinally, with numerous small granules which are very marked in the anterior groove; tubercles larger, sunken and surrounded by granules actinally, and crowded in lines on the post-oral region.

*Fossil.* Cretaceous: England, Europe, Africa, S. Hindostan. Eocene: Asia (Sind). Miocene: Australia.

Lovén has pointed out that the episternum is not developed in this genus, which is nevertheless amphisternous, the arrangement foreshadowing that of the later Spatangoids. The forms included in the genus have an Ethmophract apical system, the fifth basal plate being absent, and the madreporite sometimes slightly separates the postero-lateral basals. There are some plates of the bivium between the petaloid part and the subanal fasciole which are uniporous; but all the plates of the trivium are biporous. The petaloid arrangement is rather imperfect, the distal ends not absolutely closing; usually the grooves between the plates of the ambulacra, except the anterior, are very distinct.

Subgenus *BRISSOPNEUSTES*, Cotteau, 1886 (genus), *Bull. Soc. Zool. de France*, vol. xi. p. 712, pl. xxiii. figs. 9-12.

Test small, oval, ovoid, elongate, narrowest and truncated posteriorly, tumid dorsally and slightly actinally.

Apical system excentric in front, small; four basal plates in contact and three are perforated. The madreporite in the right anterior imperforate basal plate. The anterior poriferous zone of the antero-lateral ambulacra smaller than the posterior zone.

*Fossil.* Eocene: Europe.

In dealing with the affinities of this somewhat doubtful genus, M. Cotteau compared it with *Isopneustes*, Pomel, 1883, Thèses, p. 43, a genus (?) which was defined in relation to *Micraster*, and has "pas de fasciole péripétale, ni probablement de sous-anal."

M. Seunes, 1888, *Bull. Soc. Géol. de France*, vol. xvi. p. 793, states that there is a partial peripetalous fasciole in *Isopneustes*, and hence the genus has not been sufficiently diagnosed.

Genus *BRISSUS*, Klein, 1734, *Nat. Disp. Ech.* p. 36. Gray, 1825, *Ann. Phil.* p. 9. Agassiz & Desor, 1847, *Cat. Rais., Ann. d.*

*Sci. Nat.* sér. 3, vol. viii. p. 12. Desor, 1858, *Synopsis*, p. 403. A. Agassiz, 1872, *Revision*, pp. 96, 356, 596. Bolau, 1872, *Spatang. d. Hamb. Mus.* p. 11. Lovén, 1874, *Etudes*, figs. 43, 122, 123, 202-204. (*Amended.*)

Syn. *Brissomorpha*, Laube; *Heterobrissus*, Manz. & Mazz.

Test moderate and large, ovoid in tumid marginal outline and narrowest posteriorly, regularly convex but depressed dorsally, tumid and convex actinally, except in front of the peristome, truncated obliquely downwards and forwards at the posterior surface below the ambitus, or straight; no anterior groove beyond some slight local depression.

Apical system excentric in front, the four basal plates perforated, and the madreporite extending from the right anterior basal, centrally, and thence posteriorly so as to separate the posterolateral basal and radial plates.

Ambulacra diverse, the anterior flush or in a very slight depression; the pairs of pores small and closest abactinally; anterolateral ambulacra very divergent, nearly forming a straight transverse line, in grooves of varying depth, the petaloid parts shorter than the corresponding parts of the postero-lateral ambulacra, which are comparatively close together; the pores of the inner rows of a round or slightly elongate shape, and those of the outer rows elongate; petals with narrow interporiferous areas and the pairs tending to close, the distal ends of the postero-lateral petals diverging outwards or not. Actinally the postero-lateral ambulacra are very narrow and long, with few single pores, more numerous at the peristome.

Interradia large actinally, with very large second and third plates; normal heteronomy of interradium I.

Peristome excentric in front, semilunar, with a large projecting posterior labrum, behind which is a broad amphisternum; spheridia numerous. Periproct in the posterior truncation, large.

A peripetalous fasciole entering the lateral interradia considerably, sinuous more or less; a subanal fasciole surrounding a broad area including six ambulacral plates, the upper part of the fasciole concave. Ornamentation of very crowded almost homogeneous tubercles abactinally, and of slightly larger tubercles actinally; rarely some larger tubercles within the peripetalous fasciole. Spines slender, moderately long on the anterior part of the test; dark brown, yellow, to silver grey.

*Fossil.* Crag: England. Eocene, Miocene, Pliocene: Europe. Miocene: Asia (Sind and Madura). Tertiary: N. America, West Indies.

*Recent.* Arctic Seas, N. Atlantic to Azores, Mediterranean, West Indies and Brazil, Pacific, W. coast of America. 7-450 fms.

This definition covers the recent forms and most of the Tertiary species, but Wright's *B. tuberculatus* has necessitated the addition regarding the occasional presence of larger tubercles within the peripetalous fasciole, as in *Metalia*.

The genus *Brissomorpha*, Laube, 1871, is similar to *Brissus*; and the genus *Heterobrissus*, Manzoni and Mazzetti, 1877, is unsatisfactory on account of the indifferent state of preservation of the specimens of the sole species; it may be a *Brissus*.

*Brissus depressus*, a form which has never been obtained in a condition of preservation worthy of description, has been made the type of a new genus, *Leiopneustes*, by M. Cotteau, 1885, Pal. Franç., Terr. Crét. p. 123. Considering that it is written "fascioles absent or very slightly apparent," the value of the genus is problematical.

Subgenus MEOMA, Gray, 1851 (genus), *Ann. & Mag. Nat. Hist.* vol. vii. p. 132; 1855, *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 56. Lütken, 1863 (pub. 1864), *Vid. Medd. f. Nat. For. i Kjöb.* p. 120. A. Agassiz, *Revision*, 1872-74 (subgenus), pp. 358, 603. Lovén, 1874, *Études*, pl. 35.

Test moderately stout, cordiform, the paired ambulacra sunken in deep grooves, antero-lateral divergent.

Peripetalous fasciole slender, flexuous, entering the interradia between the petals. A subanal fasciole slender and incomplete above, a slender offshoot passing abactinally on either side of the periproct.

*Fossil.* Tertiary: Cuba. Miocene: W. Sind. The genus is not represented in the Australian Tertiaries.

*Recent.* Gulf of California, Acapulco, West-Indian Islands, Gulf of Florida. 242 fms.

Genus SPATANGOMORPHA, Böhm, 1882, *Denksch. d. kais. Akad. Wiss. Wien*, Bd. xlv. p. 367.

Test moderate, elongate oval, depressed, notched anteriorly, highest and truncated posteriorly, depending below the periproct.

Anterior ambulacrum in a shallow groove; the paired ambulacra shallow, lanceolate, moderately long; pores somewhat diminished near the apex. Odd interradium separated, actinally, from the labrum by the junction of the broad posterior ambulacral areas.

Peristome excentric in front, semilunar; sternum nipped in greatly posteriorly. Periproct high up in the posterior truncation.

A large subanal fasciole, with at least eight pairs of ambulacral plates and pores included. Large sunken primary tubercles and granules, the former absent in the posterior interradium. A peripetalous fasciole limiting and bounding the tubercular areas.

*Fossil.* Tertiary: Madura, Java.

The genus is remarkable on account of the unusual number of ambulacral plates implicated in the subanal fasciole and for the junction of the ambulacra actinally, so as to separate the sternum from the peristome.

Genus TROSCHELIA, *Duncan & Sladen*, 1883, *Pal. Ind.* ser. xiv., *Monogr. Tert. Echin. Kachh and Kattywar*, p. 67, pl. vii. figs. 9-12, and pl. xi. fig. 5.

Test rather large, long, oval, high, notched anteriorly, truncated posteriorly, slightly convex actinally.

Apical system slightly excentric in front; four perforated basal plates, the madreporite in the right anterior, and passing centrally, separating the postero-lateral basals and the posterior radials also, extending into the posterior interradium.

Ambulacra all in deep grooves; pores small and elongate in the anterior ambulacrum; large, except close to the apical system where they are minute, in the other ambulacra; petals open at the extremity close to the fasciole.

Peristome slightly excentric in front, broader than long, posterior lip well developed. Actinal plastron narrow. Periproct supramarginal, in the truncation.

Interradia with large sunken tubercles except in the posterior interradium. A peripetalous and a subanal fasciole.

*Fossil.* Miocene: Kachh.

Agassiz and Desor defined the genus *Plagionotus* in 1847, a name unfortunately preoccupied in the classification of the Insecta. Gray, in the *Catal. Recent Echin. Brit. Mus.* pt. i. 1855 (not 1832 as Dames writes), p. 50, admitted the name and separated

the genus from *Metalia*, a division of the genus *Brissus* (p. 51). His types were *Plagionotus pectoralis* and *P. Desorii*. *Brissus sternalis*, Lamk., sp., was his type of *Metalia*. A. Agassiz, 1872, Revision, p. 144, placed *Plagionotus* and *Metalia* as synonymous, and chose the latter subgeneric name to include *Plagionotus pectoralis* and *Metalia sternalis*. Since the time of the 'Revision,' the describers of recent Echinoidea have followed A. Agassiz; but that excellent palæontologist Dames has placed *Brissopsis* and *Toxobrissus* as synonyms of *Metalia*. It appears correct to admit the name *Metalia* instead of *Plagionotus*, to unite the species separated by Gray under this genus, and to place *Brissopsis* as an independent genus, with *Toxobrissus* and *Kleinia* as its synonyms.

Genus METALIA, Gray, 1855 (division), *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 51. A. Agassiz, 1872 (subgenus), *Revision*, pp. 144, 360. Lovén, 1874, *Etudes*, pl. 40, sub *Plagionotus*. (Enlarged.)

Syn. *Plagionotus*, Ag. and Desor, 1847, Gray, 1855, Lütken, 1863; *Xanthobrissus*, A. Ag., 1863; *Brissus*, Martens, 1869; *Brissopsis*, sensu Dames, 1877.

Test thin, moderate to very large, depressed, elliptical or ovoid in more or less wavy marginal outline, slightly indented anteriorly and truncated posteriorly, lowly arched or nearly flat abactinally, tumid above the margin, the edge of which is sharp; actinally comparatively flat.

Apical system excentric in front; the four basal plates perforated; the madreporite extending centrally and posteriorly, separating the postero-lateral basal and radial plates.

Ambulacra diverse; the anterior in a very shallow groove which may be absent near the apex, its pairs of pores rather distant and small; the petaloid parts of the paired ambulacra in variably sunken grooves, narrow, unequal and long, their pairs of pores large, nearly closing, with narrow interporiferous areas; anterior petals divergent, long, and straight or curved, those of the postero-lateral petals similar but rather close, and the zones bending with the distal ends flaring outwards or not, longer than those of the antero-lateral; actinally the postero-lateral ambulacral areas are long and narrow.

Interradia large, especially actinally, where the second and

third plates form much of the surface on either side of the narrow amphisternum, which, with the rest of the surface, is comparatively flat. Normal heteronomy of the interradius I. Great nipping-in of the interradial plates below the periproct.

Peristome excentric in front, crescent-shaped or subcircular, with a well-developed posterior labrum; the plates of the membrane well-developed. The periproct posterior and pear-shaped, in the truncated posterior surface, plated largely.

A peripetalous fasciole, elliptical, undulating or not. A broad subanal fasciole, surrounding a broad area, including six ambulacral plates on either side and grooves radiating to their pores. An incomplete anal fasciole, a vertical and small branch passing from the subanal or from a horizontal fasciole placed immediately above it, upwards on either side of the periproct, or in that direction.

Ornamentation abactinally either of very small close tubercles, the largest on the flanks of the anterior groove, or there may be numerous, yet distant, large primary tubercles in the lateral interradia, within the peripetalous fasciole. Beyond the fasciole the small tubercles gradually increase in size to the ambulacra at the peristome. Spines short, slender, curved, largest actinally and with a milled ring. Spheridia numerous, in groups in all the ambulacra.

*Fossil.* Eocene: Europe, Asia. Tertiary: N. America, W. Indies, Malta, Italy.

*Recent.* West Indian Islands, Florida, Mexico, Red Sea, Pacific Islands, East Indian Islands, Australia, Mauritius, E. Brazil, Sherboro Island, California, Mediterranean. Shallow water to 156 fms.

Genus RHINOBRISUS, *A. Agassiz*, 1872, *Bull. Mus. Comp. Zoöl.* p. 111; *Revision*, 1872-4, p. 590; 1881, *Report on 'Challenger' Echini*, p. 186; 1883, *Report on 'Blake' Echini*, p. 67.

Test moderate in size, very thin, longer than broad and broader than high. Outline from above ovoid, with a narrow posterior end; broadest on a line with the apical system, which is nearly central or slightly in front. Vertex of the test posterior, and the posterior surface is tall, truncated, and hollowed transversely.

Apical system small, with four basal plates with large genital

openings. Madreporite extending backwards and separating the posterior radial plates.

Odd ambulacrum flush with the test, its pores exceedingly small. Lateral ambulacra short, sunken, subpetaloid; pores large and the poriferous zone broader than the interporiferous. Posterior ambulacra the longest. Ambulacra wide around the peristome and on either side of the actinal plastron.

Peristome broad, excentric in front, with a large posterior lip. Periproct high in the posterior extremity. Actinal plastron amphisternous, long, and prolonged posteriorly into a short beak, keeled along the median line. Three fascioles—a peripetalous, an anal, and an independent subanal fasciole.

Tubercles very small and numerous dorsally, and larger and with a raised scrobicular surface actinally. Large tufted ambulacral tubes close to the peristome. Spines small, curved.

*Recent.* China, Tahiti, shores of Belúchistán.

There is no doubt about the sunken nature of the lateral and posterior ambulacra in the species from the Pacific and Indian Seas, and that the outer terminations of the petals of the ambulacra are prevented from closing by the peripetalous fasciole. The madreporite is large and separates the basals, and extends backwards well into the interradium. Now none of these characters occur in a species which A. Agassiz refers to *Rhinobrissus* with an expression of doubt (Report on the 'Blake' Echini, 1883, p. 67). The figures given by Agassiz, pls. xxiii. and xxvi., show a most interesting form which is well deserving of the pains its describer took about its details and the relation which they bear to ancient forms of Spatangoids. He considers that the species will probably form the basis of a subgenus of *Rhinobrissus* which will hold to it very much the same relation which *Periaster* holds to the true species of *Schizaster*. But it must be said that the Caribbean Sea is not the home of the genus, and that the immature forms of the Indian species have the true generic characters given above and that the *Micraster*-look is wanting in them. The genus is not known in the fossil state, and the species *R. pyramidalis*, Agass., is not a variable one. It will be best to place the Caribbean form near the genera *Linopneustes* and *Cionobrissus* and in a new genus, *Neopneustes* (page 258).

Genus *BRISSOPSIS*, Agassiz, 1840, *Cat. Syst. Ectyp.* p. 16; 1847, *Cat. Rais. d'Éch., Ann. d. Sci. Nat. sér. 3*, vol. viii. p. 15. Gray, 1855, *Cat. Rec. Ech. Brit. Mus.* p. 55. Desor, 1858, *Synopsis*, p. 378. Lovén, 1874, *Études*, pls. xii. & xxxvi. A. Agassiz, 1872-4, *Revision*, pp. 354, 593. Dames, 1877, *Palæontographica*, Bd. xxv. p. 678. Duncan & Sladen, 1884, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind.*, pt. iii. p. 203. A. Agassiz, 1883, 'Blake' *Echini*, p. 69. (Amended.)

Syn. *Kleinia*, Gray; *Toxobrissus*, Desor; *Deakia*, Pavey; *Verbeekia*, Fritsch, 1877.

Test thin, moderate in size, ovoid or elongate-oval-elliptical in tumid marginal outline, depressed, lowly tumid dorsally, rounded in front and with a variable, shallow, anterior groove, truncated posteriorly, projecting and convex actinally and behind the peristome, or subglobular.

Apical system central or excentric in front; four basal plates; the pores large; the madreporite in the right anterior basal and passing centrally in the system and posteriorly so as to separate the posterior radial plates and some of the posterior interradial plates also.

Ambulacra diverse, unequal; the anterior slightly sunken dorsally, with small pairs of close pores most numerous abactinally; the antero-lateral sunken, subpetaloid, short, equal to but may be longer than the posterior pair, straight, divergent, or curved more or less; pairs of pores large and in parallel rows, with small interporiferous areas. Postero-lateral ambulacra straight or curved, sunken; pairs of pores as in the antero-lateral, but the anterior row may become continuous with the posterior row of the antero-lateral ambulacra, subpetaloid and tending or not to close at the fasciole; actinally the areas are bare and large, those of the postero-lateral form wide areas at the sides of the plastron, and four (the 6-9 inclusive) plates of the rows nearest the plastron are angular, with large pores, and are within the subanal fasciole.

Interradia narrow apically, large actinally; the right posterior with normal heteronomy of its plates (union of 2 and 3 of series *a*). A symmetrical amphisternum. Tubercles small and crowded abactinally, larger actinally, largest at the margins of the bare ambulacra near the peristome. Periproct, in the truncated posterior surface, elliptical or ovoid, longitudinal.



A subanal fasciole, concave towards the distant periproct, with or without anal branches ; a peripetalous fasciole well developed, more or less flexuous. Plates of the membranes of the peristome and periproct largest at the edges and smaller near the orifices.

*Fossil.* Eocene: England, Europe, Asia, Java. Miocene: Europe, N. America, W. Indies. Pliocene: England, Europe.

*Recent.* North Atlantic, Norwegian and British seas, Mediterranean, Florida Gulf-stream, Sombrero, Caribbean Islands, Formosa, Siam, East Indies, New Caledonia, Luzon, Tahiti, New Zealand. Range from 1100 to 2435 fms.

The curving of the paired ambulacra is well seen in the Sindian species, and it is evident that such a character is not sufficient to separate a new genus ; moreover the continuation of the rows of pairs of pores so as to form a curve across the postero-lateral interradia is subject to great variation. The general shape of individuals of the same species is remarkable and has necessitated the introduction of an alteration in the definition of the genus ; this is the result of A. Agassiz's examination of the Echini of the 'Blake' dredging-expedition.

M. Cotteau defined a genus *Cyclaster* in 1856, and Desor placed it as a synonym of *Brissopsis* in his 'Synopsis,' 1858. In 1863 M. Cotteau reasserted the right of *Cyclaster* to a generic position, and wrote that *Brissopsis* differed because it had an anterior groove and very slightly divergent and atrophied paired ambulacra. Dames described and drew two species of *Cyclaster* in 'Palæontographica,' 1877, Bd. xxv.; and his figures and descriptions agree with M. Cotteau's ideas ; but there is no vestige of a peripetalous fasciole, and there are four closely-placed genital pores. It is possible that the fasciole may have been worn off ; nevertheless the ornamentation of the test is given without any evidence of it. Since that time several species have been removed from *Cyclaster* by M. Cotteau, and a fresh generic character has been added by him to which exception must be taken.

The characters relied upon are the absence of an anterior ambital groove, the divergent antero-lateral ambulacra, a peripetalous fasciole which is somewhat angular, a subanal fasciole, and the presence of only three genital pores, that of the right anterior basal plate being absent ; the extension of the madreporite centrally, with separation of the posterior basal plates. In 1887,

however, M. Cotteau admitted *C. Gourdoni*, which he showed has an imperfect peripetalous fasciole and a test differently shaped from that of the type.

The researches of A. Agassiz regarding the recent species of *Brissopsis* in the W. Indies have proved that some forms have divergent antero-lateral ambulacra, especially the young, that there is considerable variation in the depth of the ambital groove, and that during growth the ambulacra are closer. (A. Agassiz, 1872-74, Revision, pl. xix. figs. 8, 9; 1883, 'Blake' Echini, pl. xxvi.)

The presence of four genital pores in some and three in other species is not important; and the abortion of a duct and its gland is of no more classificatory value in this group than it is in others. The position of *Cyclaster* is that of a subgenus.

Subgenus CYCLASTER, Cotteau in *Leymerie et Cotteau* (genus), 1856, *Cat. Éch. Foss. de Pyrén.* p. 27 (*Extr. Bull. Soc. Géol. de Fr.* sér. 2, vol. xiii.); 1863, *Éch. Foss. des Pyrén., Cong. Sci. de France*, 28 Sept. vol. iii. p. 57; 1887, *Pal. Fr., Terr. Éocène*, p. 447, pl. 123, and *Bull. Soc. Zool. de Fr.* vol. xii. pp. 564 & 632.

Anterior groove slight abactinally, lost at the ambitus. Antero-lateral ambulacra divergent.

Apical system with three or four genital pores, and a central madreporite separating the posterior basal plates. Peripetalous fasciole subcircular, often more or less deficient; a subanal fasciole.

*Fossil.* Eocene: Europe, N. Africa?

GENUS BRISSOPATAGUS, Cotteau, 1863, *Éch. Foss. de Pyrén.* p. 143. *Dames*, 1877, *Palæontog.* Bd. xxv. p. 82, pl. xi. fig. 2. *Duncan & Sladen*, 1884, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, p. 226. (*Amended.*)

Test of medium size, oval, moderately tumid abactinally, lower and subcarinate posteriorly, flat actinally, anterior groove moderate at the ambitus, but small abactinally; broad depressed areas around and including the petaloid parts of the lateral ambulacra; a definite interradiial ridge separating the lateral petals.

Apical system excentric in front. Anterior ambulacrum with small pores and in a slight depression; anterior pair short, widely divergent, much curved, concavity forwards, not closing; pores

large; posterior pair longest, curved, with the concavity outwards, unclosed distally; all in the depressions of the test, forming an acute angle at the apex.

Peristome excentric in front, subcircular. Periproct elliptical, posterior. Fascioles: a peripetalous and a subanal.

*Fossil.* Eocene: Europe, Asia, Sind; and Java (Tertiary).

Dames drew a distinct peripetalous fasciole; and in Duncan and Sladen's specimens there is every indication of a subanal.

In the species described by Dames there are some primary tubercles scattered in the lateral interradia.

The genus should come near *Brissopsis*.

GENUS SPATANGUS, Klein, 1734, *Nat. Disp. Ech.* p. 33. *Lamarck*, 1801, *Syst. Anim. s. Vert.* p. 348. *Gray*, 1825, *Ann. Phil.* vol. x. p. 8; 1855, *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 46. *Desor*, 1858, *Synopsis*, p. 419. *A. Agassiz*, 1872-74, *Revision*, pp. 158, 564. *Lovén*, 1874, *Études*, pls. 208-212.

Test thin, large, cordiform in marginal outline, broad, rounded and grooved anteriorly, truncated at the narrower and oblique posterior surface, dorsally slanting upwards and backwards, depressed, never as high as broad.

Apical system small, slightly excentric in front and in front of the vertex; four basal plates perforated; and the madreporite extending between the postero-lateral basal plates and between the posterior radial plates into the interradium. Anterior ambulacrum in the broad deep groove; pairs of small pores distant. Antero-lateral ambulacra with the petaloid parts broad, long, divergent; the interporiferous areas tumid and flush; the poriferous zones broad, sunken; the pores small in the anterior zone near the apex, large where the zones are large, closing at an angle distally; anterior poriferous zone may be ill-developed. Postero-lateral ambulacra broad, petaloid, closed, subequal to the antero-lateral, and with large flush interporiferous areas and sunken poriferous zones. Actinally the ambulacra form most of the peristomial margin anteriorly and at the sides; and the postero-lateral ambulacra are well developed, the 6-8 plates of the inner zones being within the subanal fasciole, and two with large perforations.

Peristome excentric in front, with a projecting labrum; an amphisternum. Periproct large, supramarginal, elliptical, trans-

verse; both the periproct and peristomial membranes largely plated near the test.

Normal heteronomy of the right postero-lateral interradium.

A subanal fasciole only, including a broad plastron beneath the periproct.

Ornamentation abactinally, in the interradia, of large primary tubercles, slightly sunken in scrobicules, crenulate and perforated, scattered or in more or less wavy rows, and of close small secondary tubercles and a minuter tuberculation and granulation; actinally the tubercles are close and occur on the plastron. Spines longest and largest on the larger tubercles, slender, pointed, curved, striated; those of the smaller tubercles are of the same shape as the larger spines.

*Fossil.* Tertiary?: England, Europe.

*Recent.* Shores of N. Atlantic and German Oceans, Mediterranean, Azores, Bermuda, Caribbean Sea, Cape of Good Hope, Japan; Red Sea? 150 to 450 fms.

The definition of *Loncophorus*, which has been attributed to Dames, has not been discovered, unless Laube's definition of *Concophorus*, Denkschr. k. Akad. Wien, Bd. xxix. p. 36 (1869), is to be taken. Dames noticed the species called *Spatangus loncophorus*, Meneg., in his description of the "Vicent. u. Veron. Tert. Ech.," Palæontogr. 1877, p. 83, and wondered at Laube's etymology. It does not appear that a generic definition was produced.

Subgenus LONCOPHORUS, *Dames?*

Syn. *Concophorus*, Laube.

Spatangi without large primary tubercles on the interradia dorsally.

*Fossil.* Tertiary: Europe.

Genus MARETTIA, *Gray*, 1855 (a division of *Spatangus*), *Cat.*

*Rec. Ech. Brit. Mus.* pt. i. p. 48. *Lovén*, 1874, *Études*, pl. xlii. *A. Agassiz*, 1872-74, *Revision*, p. 568.

Test moderately thin, cordiform or ovoid, depressed, slightly tumid dorsally; anterior groove slight; posterior truncation narrow, actinally flat.

Apical system slightly excentric in front, small, four close

perforated basal plates ; madreporite separating the lateral basals and extending backwards.

Ambulacra diverse, the anterior narrow, with few pairs of pores ; paired ambulacra long, extending to the ambitus as broad, shallow unequal petals ; the interporiferous areas broad and tumid or not ; the poriferous zones closing, broad ; and the anterior zone of the antero-lateral ambulacra may have small or aborted pores.

Actinally the ambulacral areas are very broad posteriorly and bare ; the peristome with a long narrow labrum and a very narrow and small amphisternum. Periproct large, in the truncation.

Normal heteronomy of the right postero-lateral interradium.

Ornamentation of sunken primary tubercles crenulated and perforated, either numerous and in rows in the anterior and lateral interradia, or few in the lateral and postero-lateral interradia. A subanal fasciole, and evidences of a discontinuous peripetalous fasciole or not. Spines small, usually pointing backwards, longest actinally on either side of the ambulacra. Actinal plastron comparatively bare.

*Fossil.* Tertiary : Europe, India, Java, Australia.

*Recent.* Masbate, Borneo, China, Kingsmill Is., New Caledonia, Mauritius, Australia, Levuka Reef, Japan, Arafura Sea, South Sea. 25-800 fms.

GENUS EUPATAGUS, *Agassiz*, 1847, *Catal. Rais., Ann. d. Sci. Nat.* sér. 3, vol. viii. p. 9. *Gray*, 1855, *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 49. *Duncan & Sladen*, 1884, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, p. 235, pl. xxxviii. figs. 11-13.

*Syn. Euspatangus.*

Test of moderate size, thin, elongate, cordiform, tumid but depressed dorsally, narrowest and truncated posteriorly, actinally flat, with a slight keel.

Apical system small, excentric in front, with four basal plates, perforated ; the madreporite in the right anterior basal plate, extending to the centre and posteriorly, and separating the postero-lateral basal plates and posterior radial plates.

Ambulacra diverse ; the anterior in a feeble abactinal depression, narrow, and with distant small pairs of pores ; the paired ambulacra petaloid dorsally, long, wide, closed ; the interpori-

ferous areas broad and pointed distally, not depressed, and may be tumid; poriferous zones broad, closing, more or less sunken; pores dissimilar.

Peristome excentric in front, semilunar or subcircular, with a projecting posterior labrum. An amphisternum bounded by wide ambulacral areas. Periproct occupying much of the posterior truncation. A peripetalous fasciole, elliptical and circumscribing the petaloid parts of the ambulacra. A subanal fasciole, cordiform or broadly reniform in shape.

Tuberculation—some large perforated and crenulated scrobiculate primary tubercles, sparsely distributed upon the anterior and lateral interradia, circumscribed by the fasciole; elsewhere absent; a small tuberculation, and miliaries largest actinally. Spines short, the largest bent, tufted on the subanal area.

*Fossil.* Eocene: Europe, N. Africa, Asia. Miocene: Australia and W. Indies.

*Recent.* Australia, N. S. Wales, Arafura Sea, Van Diemen's Land.

A difficult question has arisen regarding the genus *Macropneustes*, Agassiz, 1847. The genus was founded and the diagnosis appeared in Cat. Rais., Ann. Sci. Nat. sér. 3, vol. viii. p. 8, figured in vol. vi., pl. xvi. fig. 2 (1846-47).

*Macropneustes Deshayesi* was the type, and was supposed to show the generic characters; but in after years it became evident that the specimen used by Agassiz was worn and useless; for good ones showed a subanal besides the peripetalous fasciole.

In the meantime Cotteau had founded *Peripneustes* for species which were *Macropneustes* with a subanal fasciole. To add to the confusion, some *Macropneustes* were described which tallied with the written diagnosis of Agassiz, and had no subanal fasciole.

No two writers are agreed about the nature of the ambulacra in *Macropneustes*, whether they are flush or in grooves.

There is always a desire to retain the genus of an old and valued naturalist; but it is clear that if *Macropneustes* is to be retained, *Peripneustes* must become its synonym, and the Agassizian genus must be altered. Again, if *Macropneustes* is altered, the species which tally with the original generic definition must find a home elsewhere.

Any one who has had the opportunity of studying the method

of Agassiz would not have much difficulty in believing that if he had known that there was a subanal fasciole present, he would have regarded the species as one of a group of *Eupatagus*. Dames, in considering an Eocene *Peripneustes*, noticed how close the form was to *Eupatagus*, and if *E. avellana* from Sind is examined the alliance is evident. There is, however, the question about the taxonomic value of flush and grooved ambulacra. This is to a certain extent answered, because there are forms intermediate between the perfectly flush broad ambulacra of *Eupatagus* and the grooved ambulacra of *Peripneustes*, and the Sindian species *Macropneustes speciosus* and *Eupatagus avellana* are intermediate to a certain extent.

It is proposed to make *Macropneustes* and *Peripneustes* synonymous, as Cotteau has done, and to place the first as a subgenus of *Eupatagus* (*Euspatangus*). The diagnosis of the subgenus will have to receive the addition of "a subanal fasciole, and the ambulacra semiflush or in grooves."

This will place A. Agassiz's recent *Macropneustes spatangoides*, 1883, 'Blake' Echini, p. 64, in a subgenus of *Eupatagus*.

There remain a considerable number of species which were properly considered to belong to *Macropneustes*, Agassiz, 1847 (not in reference to the type-species). Most have more or less flush ambulacral petals, and rather large tubercles within the peripetalous fasciole. They must enter *Hypsopatagus*, Pomel, 1883 (see *ante*, p. 239).

*Peripneustes* was founded by Cotteau, 1875, Kongl. Svensk. Vet.-Akad. Handl. Bd. xiii. No. 6, p. 38, pl. vii.; and considered by Dames, 1877, Palæontographica, xxv., Ech. Vic. Tert. p. 73; Duncan & Sladen, 1883, Pal. Ind. ser. xiv. Ech. Kachh & Kattywar, p. 41. *Trachypatagus*, Pomel, 1883, Thèses, p. 31, is a synonym.

Subgenus MACROPNEUSTES, Agassiz (genus), 1847, *Catal. Rais.*, *Ann. d. Sci. Nat.* sér. 3, vol. viii. p. 8. (Figure of the typical species, vol. vi. pl. xvi. figs. 2, 2a.) (Pars.) (*Enlarged.*)

Syn. *Peripneustes*, Cotteau, 1875. *Trachypatagus*, Pomel, 1883. *Stomaporus*, Cott. 1888. *Isopneustes*, Pomel?

Test thick, tumid; ambulacral petals elongate or broad, grooved or semiflush, open or imperfectly closed; poriferous zones equalling the interporiferous area in breadth. Tubercles large, upon the interradiial areas, but less projecting than the tubercles

of *Spatangus*. A lateral fasciole at the height above the margin of the test, corresponding to the ends of the ambulacral petals, passing above the anus. A subanal fasciole.

*Fossil*. Eocene; Europe; Africa; W. Indies; Asia.

*Recent*. Caribbean Sea.

*Stomaporus*, Cotteau, 1888, Compt. Rend. vol. cvii., differs because it has a sharp edge and an almost central peristome, but it can hardly be otherwise than one of this group.

Genus *NACOSPATANGUS*, *A. Agassiz*, 1873 (subgenus), *Bull. Mus.*

*Comp. Zoöl.* vol. iii. p. 189; 1874, *Zool. 'Hassler' Exped.,*

*Cat. Mus. Comp. Zoöl. Harv.* No. viii. 1. *Echini*, p. 17.

Test small, thin, ovoid in tumid marginal outline, arching regularly dorsally to the vertex, which is between the apical system and the nearly vertical posterior truncation, broadest in front of the centre, narrow behind, without an anterior groove.

Apical system slightly excentric in front, small, with three perforated basal plates, and the madreporite in the right anterior, which is imperforate.

Anterior ambulacrum different from the others, the interporiferous area covered with small secondaries and miliaries; pores small. Antero-lateral ambulacra flush, with slightly sunken poriferous zones; the anterior poriferous zone with single pores, the posterior with large pairs of pores which become single actinally. The postero-lateral ambulacra with broad poriferous zones and a narrow interporiferous area, petaloid and nearly closing.

Peristome large, excentric in front, semilunar, plated, with a broadly projecting labrum. The sternum narrow, keeled, tuberculate, flanked by broad ambulacral areas. Periproct posterior, transversely elliptical, with two concentric rows of anal plates, below it a subanal plastron with a fasciole, and a beak at the lower end of this plastron which is continuous with the actinal surface. Some anal branches of the subanal fasciole. Spines longest actinally, short and curved at the base.

*Recent*. Juan Fernandez, 65 fathoms.

The generic characters of *Gualtieria*, Desor, have necessarily been enlarged by the discovery by M. Cotteau of a subanal fasciole in the typical species from Saint Palais.



Genus *GUALTIERIA*, Desor, 1847, *Catal. Rais., Ann d. Sci. Nat.* vol. viii. p. 10. Desor, 1858, *Synopsis*, p. 406. Cotteau, 1884, *Éch. de Saint Palais*, p. 32, *Ann. d. Sc. Géol.* vol. xvi. pl. vi.

Test moderate in size, ovoid elliptical in marginal outline, rounded in front, without a deep groove, slightly narrower behind and truncated, very tumid but low dorsally, flat actinally except behind the peristome, where there is some convexity.

Apical system pentagonal, with four basal plates, each with a large pore; the madreporite extending centrally, and separating the postero-lateral basal plates, and also the posterior radial plates.

Ambulacra diverse, the anterior in a slight depression abactinally, broad, with the pairs of small pores arranged obliquely; the paired ambulacra long, flush, petaloid, tending to but not closing; the anterior poriferous zone of the antero-lateral pair with small pores near the apex, elsewhere the poriferous zones broad; the interporiferous area broad, and the whole flexuous; the postero-lateral ambulacra straighter, with the poriferous zones broad.

Peristome transverse, broadly elliptical, with a narrow labrum which is long, and has an amphisternum beyond; peristomial interradiial plates of the antero-lateral areas tuberculate, and the labrum also. The long posterior ambulacra and the anterior ambulacrum are ornamented with raised irregular prominences. Periproct posterior, high up, oval, longitudinal.

A well-defined fasciole crosses all the ambulacra at the distance of three quarters of their length from the apical system, without interfering with the nature of the pairs of pores. An elliptical bent subanal fasciole enclosing a broad area,

*Fossil.* Eocene: Europe.

Genus *LINOPNEUSTES*, A. Agassiz, 1881 (subgenus), *Report on the 'Challenger' Echini*, p. 167; 1883, '*Blake' Echini*', p. 62.

Syn. *Palæopneustes*, A. Ag. (pars).

Test large, depressed, but rather subhemispherical abactinally, the posterior part of the test sloping gradually; oval in ambital outline and notched in front, and may be slightly so posteriorly; flat actinally, with a low median keel behind the peristome.

Apical system central or slightly excentric in front, with four perforated basal plates; the madreporite extending from the right

anterior basal, centrally and posteriorly, so as to separate the postero-lateral basal plates and the posterior radial plates, and extend into the posterior interradium.

Ambulacra dissimilar, the anterior in a faint groove, with small pairs of round pores; the paired ambulacra semipetaloid, flush, all open distally, the antero-lateral widely divergent dorsally, and the postero-lateral with broad smooth plates on either side of the amphisternum; the pores of the semipetaloid parts round, but the outer pore of the pairs may be slightly elongate; pores single and distant below the semipetaloid parts, and some with peripodia around the peristome.

Peristome excentric in front, in a moderate concavity of the test, much broader than long, semi-lunar with rounded ends. Posterior labrum broad, projecting. Sternum with a more or less defined keel (amphisternous). Periproct supramarginal, circular, much plated.

Ornamentation of few or numerous small primary tubercles on each plate abactinally, edges and sutures of plates more or less plain; miliaries between the tubercles. Actinally the tubercles are subequal and more crowded, and most numerous within and around the subanal fasciole. Primary spines long or short, slender, curved, smallest actinally. Pedicellariæ long; the tri-dactyle forms with slender valves. Ambulacra with much smaller tubercles beyond the subpetaloid part than in the interradia.

A narrow peripetalous fasciole passing above the periproct; a subanal fasciole, broad or narrow heart-shaped, partly in contact with the actinal edge of the periproct.

*Recent.* Caribbean Sea, 38 to 298 fathoms; Japan and the Philippine Islands, 345 to 375 fathoms.

The species which is found in the deepest water has the shortest spines and the ambulacra the most apetaloid.

Genus NEOPNEUSTES, gen. nov.

Syn. *Rhinobrissus*, A. Agassiz, 1883, 'Blake' Echini, p. 67, pls. 23 & 26 (pars).

Test moderate in size, thin, ovoid in outline at the margin, longer than broad and broader than high; tumid abactinally, at the sides; low, broadest and tumid anteriorly, highest and truncated posteriorly; with a backward and downward projecting actinal plastron. Anterior groove absent.

Apical system slightly excentric in front, small, with four perforated basals, compact (?).

Ambulacra flush with the test, apetalous, diverse, with high plates, broad actinally, and the tentacles tufted around the peristome. The anterior ambulacrum narrow and with distant pairs of very small pores; the antero-lateral widely divergent, the postero-lateral closer.

Peristome excentric in front, broad, semilunar, with a projecting posterior lip. Actinal plastron projecting, and carrying small, short and crowded spines. Periproct small, oval, longitudinal, in the posterior truncation of the test, rather high up.

A peripetalous fasciole, sometimes ill-defined, passing around the apex about midway between it and the ambitus and crossing the ambulacra, without affecting their structure. A well-marked subanal fasciole surrounding the blunt end of the keel. Tubercles small; spines small and short, largest actinally, especially in front of the peristome.

*Recent.* Caribbean Sea, 175-233 fathoms.

The genus *Cionobrissus*, A. Agassiz, has one species, *C. revinctus*, which was dredged up in the Arafura Sea by H.M.S. 'Challenger' from 800 fathoms. The species is described in the Report on the Echinoidea of the 'Challenger,' and a previous notice both of the species and genus will be found in Proc. Amer. Acad. vol. xiv. p. 206 (1879).

The generic diagnosis reproduced in the 'Challenger' Report, p. 187 (1881), is mainly comparative. I give a diagnosis which has been abstracted from the description of the species by A. Agassiz, and tested by the drawings (Report, p. 187, pl. xxiii.).

Genus *CIONOBRISUS*, A. Agassiz, 1879, *Proc. Amer. Acad.* xiv. p. 14, p. 206; 1883, *Report on 'Challenger' Echini*, p. 187.

The test is of moderate size, long, subcylindrical, depressed, ovoid in marginal contour, with a notch in front and a beak behind, tumid above and at the sides, and with a convex actinal surface which is keeled broadly as far as a posterior beak. Test highest in the posterior third, longer than broad, and about as broad as high; rounded anteriorly, where there is a broad

and rather deep groove extending from the apex to the peristome; posteriorly there is a decided beak, above which is the periproct, circular in outline, and situated in the posterior truncation.

Apical system excentric in front; there are four basal plates, and they are perforated by the generative ducts; the madreporite is in the usual basal, and it passes backwards between the posterior basals and radials into the posterior interradium.

The ambulacra dissimilar; the anterior is sunken, and there is a pair of minute pores to each of its plates. The other ambulacra are subpetaloid, not closing, and in very slight grooves. The antero-lateral are the shortest and are nearly transverse; and in all the poriferous zones are wide, the pores being unequal, and the interporiferous areas being very narrow. The exceedingly shallow ambulacra are almost devoid of tubercles.

The interradia are unequal, the posterior being the narrowest; there are a few large primary tubercles in each within the peripetalous fasciole; elsewhere the ornamentation is of rows of large granules, but it is largest on the keel and the extremity of the beak.

Peristome excentric in front, semi-lunar, broader than long, with a small posterior lip. Periproct small, circular, many-plated, just above the plates surrounding the upper part of the beak. Beak blunt, slanting from below upwards, and with a comparatively level upper surface.

Subanal fasciole surrounding the base of the keel, ovoid, with the point downwards. Peripetalous fasciole oblique, narrow and extending across the ends of the ambulacra and cutting across the anterior groove far above the peristome. The sternum arched and keeled. The tubercles within the fascioles carry long curved spines, elsewhere they are shorter, except on the sternum.

*Recent.* Arafura Sea, 800 fathoms.

Alex. Agassiz, in his description of the genus, remarks that the genus forms a transition between his *Brissina* and the *Pourtalesiidæ*. The groove of the anterior ambulacrum is far less marked than in the *Pourtalesiidæ*. The actinal surface is not flattened as in the last-mentioned family, but arched. The arrangement of the tubercles in the interradia within the peripetalous fasciole is like that of some species of *Metalia*.

The genus *Tuberaster*, 1885, Peçon et Gauthier, Éch. foss. de

l'Algér. fasc. ix, p. 46, pl. iii. figs. 1-4, is not a satisfactory genus, and there is little evidence of an internal or of a peripetalous fasciole; indeed, Humbert does not draw a subanal. It is therefore not placed. If the fascioles were present, the genus would be *Lovenia* (see p. 263), and if absent, *Hemipatagus* (p. 222).

Genus ECHINOCARDIUM, Gray, 1825, *Annals Phil.* p. 8; 1855, *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 42. Lovén, 1874, *Études*, p. 55, pls. 3, 12, & 39; 1883, *Pourtalesia*, pls. 15, 17.

Syn. *Amphidetus*, Agass.; *Amphidotus*, Forb.

Test moderate, thin, cordiform or oval in tumid marginal outline, gibbous, deeply and broadly grooved in front, truncated and highest behind; broader than high, rather flat dorsally in front, high and broadly keeled behind the vertex, which is behind the centre. Actinally with a tumid plastron projecting downwards, a prominent labrum, and a sharp end to the plastron behind.

Apical system at the termination of the abactinal groove, excentric posteriorly, small, with four basals with large pores; the madreporite extending between and in the rear of the posterolateral basals; the radial plates small.

Anterior ambulacrum in the groove; the pores small, single, and irregular, or in pairs sometimes biserial or alternating where included within the internal fasciole, and close near the apex, where the tentacles have crenulated or stellate disks with a central bulge and one or two large spicules. The pores are larger and more distant anteriorly, where there are simple locomotive tentacles with peripodia and penicillate tentacles, as actinally. Lateral ambulacra in slight grooves, triangular in outline, widely open towards the apical system, where they are limited by the internal fasciole, narrow distally; the pairs of pores large and not numerous; the outer poriferous zones forming an arch with a slight discontinuity; the tentacles branchial. Actinally the ambulacra are plain and rather broad near the peristome, but narrow on either side of the plastron; the peripodia with capitate filaments.

Peristome large, semilunar, with well-developed membrane-plates, which are largest anteriorly, the anterior lip at a much higher level than the posterior, which is pointed and blunt. Spheridia exposed.

Interradia narrow above, large actinally, all with a single

peristomial plate; the plates 2 and 3 of zone "a" of the right posterior interradium united; an amphisternum.

Periproct, high up in the posterior face, elliptical, vertical, with well-developed plates, largest at the edge. Tubercles largest actinally, with short delicate, often spatulate spines, smaller and crowded abactinally with shorter and silky spines.

Fascioles, an internal, an anal not closing above, and a closed subanal, including three ambulacral pores on either side, belonging to 7th to 9th plates, with penicillate tentacles.

*Fossil.* Eocene: ? Europe. Miocene: Europe. Late Tertiary: England, N. America.

*Recent.* N. British and Scottish seas, N. Atlantic, Mediterranean, Japan, E. Indian seas, E. Africa, Cape of Good Hope, Australian and N. Zealand seas, Florida, N. & S. Carolina, Brazil. Littoral to 2675 fms.

Genus BREYNIA, *Desor*, 1847, *Ann. Sc. Nat. Zool. sér. 3*, vol. viii. p. 12. *Gray*, 1855, *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 45. *A. Agassiz*, 1872-4, *Revision*, p. 578. *Lovén*, 1874, *Études*, pl. 41; 1883, *Pourtalesia*, p. 55. *Duncan & Sladen*, 1885, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, p. 342, pl. lv.

Test moderate and large, thick, ovoid or cordiform in tumid marginal outline, depressed, flatly arched dorsally, highest behind the centre, rounded and notched in front, obliquely truncated behind, actinally resting on a spot anterior to the peristome, and on the posterior point of the small triangular plastron.

Apical system in front of the vertex, small, with four basal plates; the madreporite separating the basal plates, and extending posteriorly and separating the posterior radial plates.

Anterior ambulacrum in a more or less decided groove, which notches the anterior part of the test, the single pores numerous dorsally; tentacles long, slender, truncated, and with small processes; and beyond the crossing of the inner fasciole, anteriorly, the pores are larger and more distant. Lateral ambulacra triangular beyond the internal fasciole, with few small single pores converging to the apical system, within its area; the outer series of pores in pairs large and separated by costæ. The antero-lateral ambulacra nearly transverse, the postero-lateral straight or wavy and not very distant distally; pairs of pores as in the antero-lateral ambulacra. Actinally the posterior ambulacra have wide zones which limit the plastron.

Lateral interradia with large plates next to the very small peristomial ones; plates 2 and 3 of zone "a" of the right posterior interradium united. Posterior labrum elongate; sternum symmetrical and small.

Peristome semilunar, open, the margin nearly formed by ambulacral plates, the interradial plates just entering or not, except the posterior, which forms a labrum. Periproct in the posterior truncation, in a depression, ovoid. Tubercles small upon the actinal surface and on the margin. Several large perforate scrobiculate sunken primary tubercles, their mamelon small and doubtfully crenulate, in all the interradia, except the posterior, dorsally.

An internal fasciole closed; a subanal, broad, closed, environing six of the ambulacral pores on either side beyond the fifth plates; a peripetalous fasciole passing beyond the petaloid parts of the ambulacra and limiting the great tubercles.

The spines of the large tubercles, none of which are on the posterior interradium dorsally, are long, slender, curved; the actinal spines very small and slender.

*Fossil.* Miocene: E. India; Europe?

*Recent.* Red Sea, Japan, Sandwich Islands, Australia.

The species said to be Eocene by d'Archiac and Haime are now known to be Miocene, and the species described by M. Cotteau from the Antilles are not members of the genus according to Desor.

Genus LOVENIA, *Agassiz & Desor*, 1847, *Catal. Rais., Ann. d. Sci. Nat.* vol. viii. p. 10. *Gray*, 1855, *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 44. *A. Agassiz*, 1872-74, *Revision*, pp. 139, 574. *Lovén*, 1874, *Études*, pl. xliii. *Duncan*, 1877, *Quart. Journ. Geol. Soc.* vol. xxxiii p. 58, pl. iv. figs. 5-8. *McCoy*, 1879, *Pal. Vict. Geol. Surv.* decad. vi. p. 37.

Syn. *Sarsella*, *Pomel*; *Tuberaster*, *Peron*?

Test moderate or rather small in size, variable in thickness, thin or rather stout, cordiform or ovoid, depressed or rather tumid in the thick forms; an anterior groove and a posterior truncation.

Apical system excentric in front, with four perforated basals, and the madreporite separating the posterior basals and radial plates.

Ambulacra diverse, interfered with by the internal fasciole; lateral petaloid ambulacra flush, with the poriferous zones sunken, with their outer poriferous zones forming a more or less crescentic tract; the anterior poriferous zones of the antero-lateral petals nearly transverse, and with pairs of pores more or less aborted within the fasciole. Anterior ambulacrum in the groove, narrow, with small pairs within the fasciole.

Peristome excentric in front, subcircular or semilunar, the labrum narrow but very long, followed by a small amphisternum, which, with the adjacent broad ambulacral areas, forms a wide space comparatively free from tubercles. Large tubercles, abactinally, varying in number, scrobiculate, crenulate and perforated on the interradia except the posterior; in the thin tests the scrobicules form prominent parts ("purses") within the test, but not or only slightly in thick tests.

Interradia with the second and third actinal plates of the lateral interradia very large; and union of the plates 2 and 3 of zone *a* of the right posterior interradium. Periproct large, in the posterior truncation.

An internal fasciole crossing the petaloid parts of the antero-lateral ambulacra, and bounding the anterior groove and crossing the anterior odd ambulacrum. A subanal fasciole including the 6-9 inner ambulacral plates, three or more pairs of pores being large and within the elongate transverse fasciolar area on either side.

Spines, pointing backwards, long and slender actinally and laterally, short elsewhere, those within the subanal area projecting backwards in two tufts. Anal plates large near the circumference.

*Fossil.* Tertiary: Crimea, Corsica, Malta, Algiers, Java, Australia, New Zealand.

*Recent.* Guayaquil, Gulf of California, Red Sea, Australia, Philippines, Arafura Sea, Cape of Good Hope, China, Japan, Sandwich Islands. 10 to 28 fms.

The small forms with thick tests found in the Australian Tertiaries show slight vestiges of the internal scrobicular pouches, so that the genus has been modified in 1877 to receive them; there is no room for a new subgenus, such as *Sarsella*, which would include such forms according to M. Pomel (Thèses, 1883, p. 36).



The *Spatangus* referred by Dr. Wright to *S. ocellatus*, Desor, from Malta, is a true *Lovenia*.\*

\* The jumble which some palæontologists have made of *Lovenia*, *Sarsella*, *Maretia*, and *Hemipatagus* is great. It is necessary, in the first instance, to consider *Sarsella mauritanica*, Pomel, quoted by M. Cotteau, Éch. foss. de l'Algér. fasc. ix. 1885, p. 36, pl. i. M. Pomel diagnosed *Sarsella* as a subgenus of *Lovenia* without the internal swellings of the test. It has been shown that this character depends upon the thickness of the tests and is not more than of specific value. On page 37 M. Cotteau tells us that "Les fascioles [in the species under consideration] ne sont visibles sur aucun de nos exemplaires, et malgré l'oblitération des pores, près du sommet, nous ne sommes pas absolument certains qu'il y ait eu un fasciole interne. . . . Aussi avons nous longtemps hésité au sujet de l'attribution générique de cette espèce au genre *Sarsella* ou au genre *Maretia*." Further on M. Cotteau states:—"M. Pomel tout en rapellant en tête de sa description, que son genre *Sarsella* est muni de ce fasciole, n'affirme pas nettement l'avoir distingué sur ces exemplaires, et il n'en donne aucun détail." Now, although M. Cotteau had this knowledge before him, he did not put the subgenus on one side, but recognized it as a genus. The palæontologists, Messrs. Etheridge, McCoy, T. Woods, and the author of this Revision, who examined and described the Australian *Loveniæ* and classified them, have then little to thank MM. Pomel and Cotteau for, in removing their well-established genus and species to a subgenus or genus which has not had its type sufficiently defined to be of the slightest value. One would have thought that the absence of fascioles and the general appearance of the African species would have been of some weight when M. Cotteau, after doubting between *Lovenia*, *Sarsella*, and *Maretia*, thought of *Hemipatagus*, Desor, as a possible genus. He considers, however, that the resemblance is "assez loin," and adds that the two types belong to different horizons, and in fact are very easily distinguished. He then gives the distinctions to be the variation in the number of the large interradial tubercles, their being higher up in the African form, and this is also less swollen. Now these are no distinctions; and from Humbert's usual good drawing there can be little doubt that an internal fasciole never was present in many, that the petals are unlike those of *Lovenia*, and that there is great doubt about a subanal fasciole.

*Sarsella* therefore is not a good group, and whilst some of its species would be true *Loveniæ*, such as the Australian, the type *S. mauritanica*, Pomel, is a *Hemipatagus*.

M. Pomel has found out that *Breynia sulcata*, Haime, is a *Sarsella*. He has never seen the type, and I have had that advantage, and have not the slightest doubt that he is mistaken, and that it is one of the most typical of the genus *Breynia*.

IV. Division *Apetala*.

Spatangoidea with flush, apetalous, and generally uniporous, ambulacra, similar or may be diverse; plates high, few, often hexagonal. Apical system usually ethmophract; phyllodian pedicels with a simple marginal row of filaments. Fascioles present or absent.

## Section ADETES.

Genus *Genicopatagus*.*Palæobrissus*.

## Section PRYMNADETES.

Genus *Aceste*.*Aërope*.

## Section PRYMNODESMIA.

Genus *Ovulaster*.*Palæotropus*.*Homolampas*.*Argopatagus*.*Cleistechinus*.IV. Division *Apetala*.Section *Adetes*. (Without fascioles.)

Genus GENICOPATAGUS, *A. Agassiz*, 1879, *Proc. Am. Acad.* xiv. p. 210; 1881, *Report on the 'Challenger' Echini*, p. 161. *Lovén*, 1883, *Pourtalesia*, pp. 60, 76.

The test is moderate in size, circular in outline at the ambitus, rather flat and depending posteriorly actinally, tumid above, being highest and sloping roundly and sharply posteriorly and gradually in front, nearly hemispherical in outline at the sides and over the top. The apex of the test is far back, and there is the apical system.

Apical system with three perforated basal plates and a large right antero-lateral basal with the madreporite, without a pore for the genital duct, and a small accessory imperforate plate, possibly a posterior basal, placed close to the left posterior basal. The madreporite is restricted to the anterior part of the right anterior basal, which separates the posterior basals and the posterior radials. Radial plates well developed and perforated, their pore being visible from above.

Ambulacra similar, apetalous, flush, with high plates; the anterior is long; the antero-lateral ambulacra are slightly arched, concavity in front, and the posterior are wide and ornamented on either side of the plastron; number of plates small; zones increasing in width to the ambitus and then diminishing to the peristome. Pores solitary. Tubercles in the ambulacra small and from one to four to a plate with miliaries.

Interradia wide, especially the anterior, with but few plates, and these are high and carry several tubercles, which increase in number and size actinally.

Peristome excentric in front, semilunar, with a broad, long, posterior labrum. Large pedicels around the mouth. The sternum is low, and with a true plastron (amphisternous) on which the tubercles are slightly crowded. There is a slight posterior actinal keel. The periproct is small, posterior, and either close above the ambitus or at a little distance from it, and superior to a projection.

The spines are small, straight, cylindrical, and largest actinally; all are short and delicate. There are no fascioles.

*Recent.* Antarctic Ocean, from 1950 fathoms.

A. Agassiz remarks that the shape of the test varies, and some young forms are conical; but with age the test is more depressed and the keel becomes prominent, whilst the periproct gets nearer the ambitus.

The colour varies from violet to a dirty green.

The ambulacra of this genus are narrow in relation to the interradia, and in both areas there is a remarkable paucity of plates, and as the apex is far back the anterior ambulacrum is long, and the anterior interradia are large.

The ambulacral pores are shown to be single in the drawing given by Lovén in 'Pourtalesia,' p. 76, and it is evident that there is some variability in the structure of the apical system (see A. Agassiz, Report on 'Challenger' Echini, pl. xxxv a).

A. Agassiz considers that *Genicopatagus* has striking affinities with *Holaster*, *Cardiaster*, and *Toxaster*. He notices that the ambulacra in *Genicopatagus* are slightly sunken as in *Toxaster*, that their structure is that of *Cardiaster*, and that the outline of the test recalls that of *Holaster*. He shows that the genus differs from *Palæopneustes*. He considers that the apical system is more like that of *Cardiaster*, not being so elongate as in

*Holaster*. The flat actinal surface and the globular outline remind that author of *Cardiaster*, but the actinostome is more central than in *Cardiaster*.

Lovén, 'Pourtalesia,' p. 60, notices that *Genicopatagus*, in common with the other abyssal genera, is apetalous; the ambulacra are flush with the test, and only contract up to the top. The plates are few, as high as they are broad, or nearly so, are regularly hexagonal; the pores are very minute, and placed centrally or subcentrally, and the pedicels are small and simple. The description given by Lovén (p. 76) of the apical system of *Genicopatagus affinis*, A. Ag., we have taken to be generic in preference to the delineation and description given in the 'Challenger' Report, for it is probable that the specimen therein described was imperfect.

Genus PALÆOBRISUS, *A. Agassiz*, 1883, *Report on 'Blake' Exped. Ech., Mem. Mus. Comp. Zoöl. Harv.* vol. x. no. 1, p. 56, pl. xxiv.

Test moderate in size, ovoid in marginal outline, widest anteriorly; narrow and truncated posteriorly; tumid but depressed dorsally, more or less flat actinally, projecting downwards posteriorly.

Apical system excentric in front, at the vertex, small, compact; four basal plates in contact; the genital pores small in the anterior pair and large in the posterior basal plates; radial plates small.

Ambulacra diverse, flush, apetalous; the anterior with small distant pairs of pores; the paired ambulacra widely open at the ambitus, increasing in breadth from the apex, the pairs wide apart, few, the pores large and circular, remote from the apex, actinally in peripodia.

Interradia with numerous plates, with distant primary tubercles, small and of uniform size, but increasing towards the ambitus; miliaries between; primary tubercles closer actinally, but the ambulacra are bare.

Peristome semilunar, excentric in front, labrum projecting; an amphisternum. Periproct circular, low down in the posterior truncation. Tentacles of the abactinal pores broad, flat, and with small disks, the actinals fimbriated.

Primary spines small, slender, straight; miliary spines one third of the length of the others; short-stemmed, stout-headed

and large-headed tridactyle pedicellariæ on the ambulacra ; scattered upon the test irregularly are long-stemmed, large, slender, open-headed tridactyle pedicellariæ.

*Recent.* Caribbean Sea, Barbados, 82-185 fathoms.

Section *Prymnaletes*. (Subanal fasciole absent ; peripetalous fasciole present.)

Genus ACESTE, *Wyv. Thomson*, 1877, *Voyage of the 'Challenger,' Atlantic*, vol. i. p. 376, figs. 95, 96. *A. Agassiz*, 1881, *Report 'Challenger' Echini*, p. 195, pls. xxxii. & xxxiii a. *Lovén*, 1883, *Pourtalesia*, pp. 53, 88, pl. xx.

Test small and moderate in size, long, low, narrow, and ovoid or obcordate in marginal outline, broadest anteriorly, where there is a large deep groove dorsally ; narrowest posteriorly, and more or less vertically or obliquely truncated there ; test rising gradually from the anterior part to the posterior, gibbous vertex ; tumid and broadest near the dorsum, narrow actinally ; the broad abactinal groove extending far back from the anterior notch.

Apical system very excentric posteriorly, placed at the vertex, small ; two basal plates, each with a large genital pore ; the madreporite small, and either between the plates or in the right anterior basal plate ; radial plates small.

Anterior ambulacrum very broad, placed in the anterior groove, commencing far back ; the plates very broad, low, numerous ; the pores simple near the apex and double along the abactinal groove, single actinally, rows distant. Antero-lateral ambulacra flush and apetalous ; long, narrow, with tall, narrow plates ; those of the anterior zone are small and uniporous ; the plates of the posterior zone biporous. These ambulacra pass along the outside of the anterior groove to the anterior third of the test and then over the flanks to the peristome, and they are directed almost transversely abactinally. Postero-lateral ambulacra broader than the antero-lateral ; plates high and narrow abactinally, flush, apetalous, and uniporous ; actinally the plates are large and long.

Interradia : the antero-lateral narrow, the postero-lateral broader, and with the plates 2 and 3 of zone *a* of the right area united actinally.

Peristome quite anterior, vertical, at the anterior and actinal end of the groove, elliptical or subpentagonal, with a plated membrane, the largest plates towards the outer part ; mouth

subcentral; the anterior margin formed by broad ambulacral plates; peristomial interradiial plates very narrow; the labrum narrow, long, projecting slightly; a true amphisternum, which is large and prominent. Phyllodian pedicels with a double marginal series of circumferential filaments and a central five-partite bulge.

The ornamentation is small and miliary within the great groove; small primary tubercles at the edge, larger beyond the fasciole, and increasing to and over the margin of the test, crowded on the sternum, usually several tubercles on a plate; ambulacra bare actinally. A peripetalous fasciole close to the sides of the groove abactinally, crossing it in front and passing over the test between the apical system and the posterior extremity, and crossing the lateral ambulacra not far from the apical system, and not interfering with the continuity of the pores.

Periproct in the posterior truncation, circular, with numerous concentric anal plates. Spines short, some larger and spathiform, crowded on either side of the abactinal groove and upon the sternum, those surrounding the periproct long, bent, and pointed; other spines smaller and curved. Some minute mushroom-shaped spines in the anterior groove. Large tentacles within the fasciole and in the anterior ambulacra, with huge disks, furnished with very numerous radiating, narrow, pointed supports in a circle.

*Recent.* Sandwich Islands to Low Archipelago, Buenos Ayres to Tristan da Cunha, Canaries; 600–1900 to 2600 fathoms.

The genus *Aërope* had a somewhat remarkable origin. The 'Challenger' Expedition started at the close of the year 1872, and whilst in the Bay of Biscay, in that year, according to the Report on the 'Challenger' Echini by A. Agassiz, 1881, p. 194, a species of the genus was dredged, and a similar form was got from the coast of Portugal in 1873. Nothing was heard of the extraordinary form, and no notice was published of it, until Sir Wyville Thomson in 1877 described other specimens, which were dredged in May 1873 between Berruda and 130 miles S.E. of Sandy Hook. These specimens were described in Sir Wyville Thomson's unofficial work, 'Voyage of the Challenger,' Atlantic, i. p. 380, fig. 99 (1877). The description given is of a species, not of the genus.

In 1875 the 'Valorous' sailed with the late Dr. J. Gwyn Jeffreys and Mr. (now Dr.) Herbert Carpenter, and in a deep

dredging in Davis's Straits an unknown Echinoderm was got. This form, with a great number of Invertebrata, was confided to the Rev. A. Norman for description. In June 1876 Mr. Norman's report was read before the Royal Society, as forming part of that of the director of the Expedition (Proc. Roy. Soc. xxv. pp. 202-215, June 1876). The notice is excellent, and it is stated before the description, "a remarkable new genus of Echinoidea occurred here." On p. 212 it is written, "This new and most interesting form will be named *Ærope rostrata* by Sir W. Thomson;" and there is a footnote, "When this description was read I had suggested a name for the present species; but having since learnt from Sir W. Thomson that it has also been procured in the 'Challenger' Expedition, I gladly adopt the above name under which I found that he was about to describe it." The 'Challenger' returned in May 1876.

Sir Wyville Thomson handed over the Echini of the 'Challenger' to their able describer A. Agassiz in 1876, who published a differential and critical definition of the genus *Ærope* in the official report, 1881.

He left Mr. Norman out of the matter, and his references to the Royal Society's Proceedings by mistake relate to Sir W. Thomson instead of Mr. Norman. A. Agassiz wrote, 'Challenger' Report, p. 190, that the genus was first described by Sir W. Thomson in the Voyage of the 'Challenger,' vol. ii. p. 28 (correct reference vol. i. p. 380). There is no doubt that A. Agassiz had not had the opportunity of knowing that Mr. Norman's description was the best and earliest.

Genus *ÆROPE* (described without a name, 1876, *A. Norman*, Proc. Royal Soc. 1876, p. 211), *Wyv. Thomson*, 1877, *Voyage of the 'Challenger,' Atlantic*, vol. i. p. 380, fig. 90. *A. Agassiz*, 1881, *Report on the 'Challenger' Echini*, p. 190, pls. xxxiii., xxxiii a.

Test small to rather large, rather stout, very elongate, generally cylindrical, higher than broad, oval and acuminate posteriorly, slightly rounded in front in marginal outline, and sloping anteriorly, highest centrally, and convex actinally behind the peristome.

Apical system excentric in front, within the anterior slope, with four basal plates, perforated, the ducts ending in as many tubes; madreporite in the right anterior plate extending to the centre; antero-lateral radial plates small, and separating the

lateral basal plates, but not uniting centrally in consequence of the madreporite.

Anterior ambulacrum in the front part of the depression, larger than the others; its rows of pairs of pores far apart and the pores larger than those of the other ambulacra. The antero-lateral divergent, and the postero-lateral passing back at a small angle and very long; both narrow, flush, apetalous, with small plates, each with a pair of pores above the ambitus, and with large pores in peripodia around the peristome; the plates of the posterior pair very long actinally on either side of the sternum; pairs of pores very few in number.

Interradia with very much larger plates than the ambulacra, the postero-lateral very broad, a long narrow peristomial plate in front of a true and more or less keeled amphisternum; other peristomial plates narrow.

Peristome excentric in front, circular, with the labrum projecting on a lower level than the opening. Periproct dorsal, flush, and elliptical, pointed forwards, somewhat remote from the posterior end of the test; membrane with concentric plates.

Tubercles small, somewhat numerous on the abactinal inter-radial plates, one on each ambulacral plate dorsally, largest on the sternum.

A broad fasciole extending obliquely from close behind the vertex, which is subcentral, around the edges of the anterior depression and curving actinally close to the anterior margin, crossing the ambulacra and including a broadly elliptical space; apparently the pores of the paired ambulacra are uniporous below the fasciole.

A few very large disciferous tentacles in two rows in the anterior ambulacrum; and some large penicillate tentacles around the peristome. Spines, some club-shaped, the others acuminate cylindrical; the first kind commonest actinally and behind the fasciole, spathiform and large upon the sternum, hollow, longitudinally ridged.

*Recent.* Davis Straits, Bay of Biscay, coast of Portugal, E. coast of U. States, 130 miles from Sandy Hook, Arafura Sea. 800 to 1750 fathoms.

In the beautiful drawing given in the 'Challenger' Report, pl. xxxiii *a.* fig. 10, there is a possibility of the existence of a fifth imperforate basal plate. It is very important that separate descriptions of the specimens from Davis Straits and the remote Arafura Sea should be presented to science.



Section *Pyrmnodesmia*.

(A subanal fasciole, others may be present.)

GENUS OVULASTER, *Cotteau*, 1884, *Bull. Soc. Zool. de France*, vol. ix. p. 328. *Seunes*, 1888, *Bull. Soc. Géol. Fr. sér. 3*, vol. xvi. p. 803.

Test of moderate size, thick, elongate, rounded and slightly enlarged in front, sub-acuminated and truncated behind, slightly keeled above and tumid actinally, very faintly grooved in front.

Apex very excentric in front. Apical system with the four lateral basal plates in contact, the madreporite in the right anterior plate.

Ambulacra dissimilar, flush with the test and apetalous; the anterior narrow, and its pores less apparent than those of the others. Antero-lateral ambulacra very widely divergent, with the poriferous zones arched concavity forwards. All the paired ambulacra are narrow, barely flexuous and very angular at the apex; poriferous zones composed of small pores lodged in fossettes, arranged in close pairs near the apex and much more distant towards the peristome. The pores open quite at the base of the plates, which are tall.

Tubercles abundant, scrobiculate, the intermediate granules homogeneous. The peristome is subcircular, slightly sunken, and very excentric in front; the sternum long and sub-pointed. The periproct is oval, high up, and is near the summit of the posterior surface. A subanal fasciole.

*Fossil*. Cretaceous: Europe (France).

GENUS PALÆOTROPUS, *Lovén*, 1872, *Etudes*, p. 17, pls. xii., xiii., & xxxii. *A. Agassiz*, 1881, *Report on Challenger' Echini*, p. 157; 1883, *Report on 'Blake' Echini*, p. 54, pl. xviii. *Lovén*, 1883, *Pourtalesia*, p. 78, fig. 208.

The test is small, has an ovoid contour, is uniformly tumid above, moderately convex below, and is slightly flattened posteriorly, and well rounded at the sides, smooth.

The apical system is slightly excentric in front, consolidated, and more or less pentagonal. The basal plates are fused in a mass, and there are no sutures; the madreporite is indicated by a fissure, or by pores near the position of the right anterior plate. The radial plates are distinct, small, and perforated, and the posterior pair are separated. There are but two generative ducts having their pores at the tops of two large tubular eminences.

The ambulacra are flush with the test, apetalous, and the five or six plates nearest the apex are small, in a single series; lower down and to the peristome there is a double series of ambulacral plates. There is but one pore to a plate except at the peristomial edge, where there are two in some plates. A subcircular subanal fasciole only. The internal plates 6, 7, 8 of the broad bivium are elongate and are within the episternal angle in relation to the fasciole, and plates 7 and 8 have their pores transposed to the episternal side of the suture. Phylloidian tentacles with a single marginal row of filaments. Tubercles small, several on a plate, largest actinally.

Peristome widely open, more or less semilunar, with a small labrum. The second and third plates of zone *a* in the right posterior interradium are fused. An amphisternum, and the episternum is symmetrical and well developed. The periproct is oval, longitudinal, placed towards the middle of the posterior face, and it is comprised within the first five abdominal plates, being separated from the episternum by one double plate only. Oral and periproctal membrane-plates well developed.

*Recent.* Azores, 250 fms.; Caribbean Sea, 82-242 fms.; between Bermuda and mainland, 233 fms.; Philippines, 375 fms.

The typical species is *P. Josephinæ*, Lovén.

The interesting type of this genus was dredged off the Josephine Bank, and it measured eleven millimetres. It was doubtless immature, and upon the admission of that supposition changes will probably have to be made in the diagnosis. Other specimens of *Palæotropus Josephinæ*, Lovén, have been discovered in the Caribbean Sea; and A. Agassiz wrote upon them in the 'Blake' Expedition, Report on the Echini, p. 53 (1883). A small specimen 10 millim. in length did not differ from that figured by Lovén.

Older specimens measuring 23 millim. in length (plate xxiii.) are comparatively less globular and more flattened, but otherwise do not vary greatly in appearance from the younger specimens.

A. Agassiz remarks that there is little difference in the arrangement of the ambulacral plates in young and old specimens; but he figures the ambulacra of his specimens with double plates near the apex. There are only two generative pores in all the types, and Agassiz remarks on the presence of the basal 5. On comparing the drawings of *Palæotropus Josephinæ* in the 'Blake

Echini,' pl. xxiii., the distinctions between them and those of Lovén seem remarkable. The apex is very excentric in front in the specimens figured by Agassiz, the ambulacra are double near the apex, the apical system is longest transversely, and the fifth basal is visible. The shape of the mouth and of the anus, the visibility of the pentagonal fasciole from below, and indeed the shape of the test as a whole differ in the two forms. These are startling differences to find in the same species.

Agassiz mentions *Palæotropus Thomsoni*, and the diagnosis he gives ('Blake Echini,' p. 55) shows that the form differs most strikingly from all the other specimens of *Palæotropus*. It is closely covered with uniform tubercles on the abactinal side, and has a proportionally greater number of coronal plates and a high test with a keeled posterior interradium. The apex is more posterior than in *P. Josephinæ*. He remarks that the species "differs most strikingly from all the other species," and refers to the bare posterior lateral ambulacra actinally, the very elongate plastron, and the longitudinally elongate fasciole. No illustration is given of the species, which was dredged from a depth of 233 fathoms between Bermuda and the mainland.

Another species was described by A. Agassiz in the Report on the 'Challenger' Echini, p. 158 (1881). In this, *Palæotropus Loveni*, there are three generative pores and no fifth basal; the mouth, anus, fasciolar space, ornamentation, and the shape differ from those of the original type; moreover there is a wide anterior ambulacral groove drawn on plate xxi. fig. 6. As this form came from the Philippines, a considerable departure from the type was to be expected. Considering the history of *Hemiaster*, it may belong to Lovén's genus.

Genus HOMOLAMPAS, *A. Agassiz*, 1872-74, *Revision of the Echini*, pp. 347, 562; 1881, *Report on the 'Challenger' Echini*, p. 163; 1883, *Report on 'Blake' Echini*, p. 87.

Syn. *Lissonotus*, A. Ag., 1869.

Test large, elongate, cordiform, notched at the anterior margin considerably, and less so posteriorly; depressed, longer than broad, broader than high, and broadest and highest in the anterior third. Very flat actinally, but with a keel in the median line of the plastron. Highest anteriorly, where it is boldly curved and precipitous, and sloping gradually posteriorly to the short truncation. A broad anterior groove.

Apical system very excentric in front, with four perforated basal plates; the madreporite large, in the usual basal, separating the lateral basals and the posterior radial plates and extending backwards. Radial plates small and distant.

Ambulacra apetalous, uniporous; the anterior ambulacrum is in the anterior groove; the lateral ambulacra are widely separated, somewhat waved, widen from the apical system to the ambitus, and thence they become narrow to the peristome. The postero-lateral are very long. The plates are rather high, and the pores are in simple series. The interradia are broad and have large plates. The peristome is semilunar, with more or less rounded angles. There is a thin labrum.

The plastron is amphisternous, is covered with a tubercular ornamentation, and is bounded laterally by the broad and comparatively bare actinal plates of the posterior lateral ambulacra. The periproct is small and oval, longest nearly vertically, and situate in the posterior face close above the margin.

The ornamentation of the interradia abactinally is of a few large primary tubercles much larger than any others, and there are secondary tubercles and miliaries in abundance. Actinally the primaries are smaller, are surrounded by a sunken scrobicule, and this is also seen from within the test as a sunken "purse," as in *Lovenia*. The spines of the large tubercles are gigantic and curved, and those of the smaller tubercles are small and curved; those of the actinal side are spathiform. There is a subanal fasciole, which is broad and pentangular, pointed downwards and with indistinct anal branches. The peripetalous fasciole is inconstant, thin, and incomplete.

*Recent.* Straits of Florida, 734-1920 fms.; coast of Brazil, 32-400 fms; and Pacific, Sandwich Islands to Low Archipelago, 2425-2475 fms.

There are two species. The type was an immature form.

Genus ARGOPATAGUS, *A. Agassiz*, 1881, *Report on the 'Challenger' Echini*, p. 160.

Test of moderate size, very thin and transparent, truncated in front and bluntly pointed behind, ovoid in marginal outline; depressed abactinally, flat actinally; broadest in the anterior two thirds, narrower posteriorly.

Apical system slightly posterior, corresponding with the summit, with four perforated basal plates; and the madreporite is in the right anterior, and passes backwards, separating the posterior basals; basal sutures obliterated.

Ambulacra flush with the test, uniporous, increasing in width to the ambitus and apetaloid, with but few plates, which are large, high, and hexagonal. The areas diminish in breadth to the peristome. The anterior ambulacrum appears to resemble the others.

The interradia have large plates and but few of them.

Peristome excentric in front, broad, but short longitudinally, more or less semilunar, and with a well-marked posterior lip which projects. Plastron well developed, amphisternous and tuberculate, contrasting with the broad plain posterior ambulacra on either side. Periproct supramarginal, circular in outline. There is a subanal fasciole only.

Tubercles of the primary kind largest and most crowded at the ambitus in all the areas, scattered over the test above the ambitus, absent near the apex, and regularly placed in the odd ambulacrum. Spines of actinal surface slender, club-shaped and hollow, with a thick shaft. Ambulacral pedicels most powerful and with small disks near the apex, and diminishing actinally. Tufted pedicels around the peristome.

*Recent.* (One species) Arafura Sea, 800 fms.

Genus *CLEISTECHINUS*, *P. de Loriol*, 1882, *Descript. des Echinides des Environs de Camerino, Mém. Soc. Phys. et Hist. Nat. de Genève*, t. xxviii. no. 3, p. 27.

The test is small, thin, depressed, tumid dorsally, oval, elongate, rounded in front, where there is no notch, low and truncated behind.

Apical system probably disconnected; the system is excentric in front, and the only specimen observed has two genital pores relatively large and very close.

The ambulacra are composed of extremely small pores, barely visible here and there. It is impossible to affirm whether the pores are single or in pairs. Ambulacral plates relatively very large, so that there are almost as many ambulacral as interradial plates. There is no anterior groove.

The peristome has a posterior, projecting lip. The periproct is oval, elongate, open at the summit of the posterior surface.

The tubercles are very unequal, some being much larger than others, and few and far between.

*Fossil.* Miocene: Europe.

It is stated in the description of the solitary species that the plastron is slightly hollowed out around the peristome, which has a very projecting lip. The ambulacra are indistinct, and it appears from the figures that they are flush with the test and not petaloid.

De Loriol places the form near *Argopatagus*, A. Agass., but notices that he cannot state anything about the presence of fascioles.

The combination of the peculiar ambulacra and the pair of close, probably disunited, generative plates (basals) with a projecting lip are dwelt upon by the careful naturalist to whom we owe the genus.

### III. Family LESKIIDÆ, Gray.

Test thin, ovoid. Apical system with three basal plates fused into one, two large genital pores only and upon conical prominences. Peristome excentric in front, pentagonal, with five angular buccal plates. Periproct circular, and with from five to seven plates. A peripetalous fasciole.

#### Genus *Palæostoma*.

Gray founded the genus *Leskia* in 1851, the name being already employed in Natural History. Subsequently Lovén in 1867 diagnosed the genus *Palæostoma*, which is identical with *Leskia*. Gray distinguished the generic characters.

Genus PALÆOSTOMA, Lovén, 1867, *Öfvers. Kongl. Svensk. Vetensk.-Akad. Förhandl.* no. 5, p. 432; 1874, *Études*, p. 50, figs. 39, 197-199; 1883, *Pourtalesia*, p. 79, pl. xvi.

Syn. *Leskia*, Gray, 1851, *Ann. & Mag. Nat. Hist.*, and 1855, *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 63.

Test thin, moderate in size, ovoid, broadest behind the centre and anteriorly, more or less narrow posteriorly, tall and subglobose abactinally, highest behind, convex actinally, anterior groove slight.

Apical system subcentral, small, three of the basal plates fused

into one; two large genital pores upon conical protuberances. Madreporite indistinct. Radial plates small, separate.

Ambulacra dissimilar, sunken, the anterior in a slight abactinal groove, the plates rather high; the pairs of small pores vertical and in two rows. Petaloid part of the antero-lateral ambulacra divergent, broad, poriferous zones broad; postero-lateral petals shorter. The plates beyond the petals broad with single pores, but narrowing greatly at the peristome; the postero-lateral areas wide on either side of the sternum, the fifth plate of the inner zone of the right posterior ambulacrum actinally pushing into the line of the posterior interradium. Phyllodian tentacles with a central protuberance and marginal filaments. Frontal tentacles with a calcareous disk and rays. Primary tubercles perforated and crenulate, numerous on the large interradial plates.

Interradia with few plates; both the antero-lateral areas with the second plates of both their zones beyond the peristomial plate united, the same union occurs in the left postero-lateral interradium. In the right postero-lateral interradium there is union of the second plates of both zones with the third plate of zone "b." The peristomial plate of the odd interradium is long; the sternum is not quite symmetrical, the second plate of zone "b" being short; the episternal plates are not parallel.

Peristome excentric in front, nearly flush, pentagonal, the greater part of the margins formed by interradial plates, the ambulacra forming the angles and very small; five triangular buccal plates. Periproct circular, near the upper extremity of the rounded posterior surface, 5-7 triangular plates on its membrane. A sinuous peripetalous fasciole. Spines and tubercles subequal, the former subulate and largest dorsally.

*Recent.* China, East Indian Islands.

#### IV. Family POUTALESIIDÆ,

(Pourtalesiadæ) *Lovén*, 1883, *Kongl. Svensk. Vet.-Akad. Handl.*  
Bd. xix. no. 7, p. 82 (Pourtalesia).

Syn. Subfamily *Pourtalesia*, *Wyv. Thoms. & A. Agass. (pars)*.

Test very elongate, subcylindrical or obconical, truncated anteriorly and broad there, tumid in the middle and rostrated or pointed posteriorly; convex or humped dorsally, flat actinally.

A deep anterior recess with the peristome vertical and at its lowest part. The periproct superior to the projecting posterior rostrum, or when there is no rostrum, placed actinally. Apical system variable, compact or disconnected. Ambulacra flush, apetalous, may be disconnected or discontinuous; pores single or slit-like. Tentacles homoiopodous. Interradia forming, or not, a continuous vertical band in the postero-lateral areas; sternum distinct or not. Spheridia absent in the anterior ambulacrum and exposed and numerous in the others. A subanal fasciole may or may not exist, but is not accompanied by modification of the ambulacral plates. Spines short, straight or curved, only crowded on the sternum.

Genus *Pourtalesia*.

*Spatagocystis*.

*Echinocrepis*.

The genus *Pourtalesia*, A. Agassiz, is one of the most interesting, and its affinities have given much trouble to the three distinguished naturalists to whom we owe the knowledge of the morphology of the species. The first species, *P. miranda*, which was used as the type of the genus by A. Agassiz, was dredged by the late M. de Pourtales off Florida, at a depth of 349 fathoms, and it was described by A. Agassiz, 1869, in Bull. Mus. Comp. Zoöl. i. p. 272. Subsequently the genus and the same species, *P. miranda*, were described in the 'Revision of the Echini,' 1872-74, p. 344, pl. xviii. The dredgings of H.M.S. 'Porcupine' yielded two other species, which were described by the late Sir Wyville Thomson in Phil. Trans. 1874, p. 747, pls. lxx. and lxxi. These species, *P. Jeffreysi* and *P. phiale* (*P. phyale*, W. T.), were got—the first-named from 317 fathoms between Färoe and Shetland, and the latter from 1215 fathoms in the Rockall Channel. An excellent general description of *P. Jeffreysi* and a very good engraving were published by the same author in his work called 'The Depths of the Sea,' 1873, p. 108.

The dredgings of the 'Challenger' in the Pacific produced no less than five new species, and they were described and figured in the Report on the Echinoidea by A. Agassiz, 1881, p. 132—*P. carinata*, *P. hispida*, *P. laguncula*, *P. ceratopyga*, and *P. rosea*. The genus has its principal quarters in the Pacific Ocean, where there are five species; and there are three species in the Atlantic, viz. *P. Jeffreysi*, *P. phiale*, and *P. miranda*. These are



all dwellers in very deep water, and indeed *P. Jeffreysi* is the only species with a moderate bathymetrical distribution.

In 1883 Prof. Sven Lovén published his great work on "*Pourtalesia*, a Genus of Echinoidea" (Kongl. Svenska Vetenskaps-Akad. Handlingar, Bd. xix.), and he had obtained specimens from the Survey of the N. Atlantic by the steamer 'Vöringen' and from A. Agassiz and Sir W. Thomson. He especially investigated *P. Jeffreysi*.

The descriptions of what Lovén very truthfully called "the most extraordinary Echinoid hitherto known," by the authors alluded to, are models of plain exactitude, and those of Sir Wyville Thomson are in his best style. There is, however, considerable diversity of opinion amongst the three naturalists regarding the alliances of the genus with extinct forms; but now that it can be said that the morphology of one of the species has been described with wonderful accuracy by Lovén, the palæontologist may pass his opinion on the subject.

There is a difficulty in associating all the species now classified under *Pourtalesia* in one genus, which has been felt by Agassiz and Lovén, and will interest the advanced students of the Echinoidea.

Can *Pourtalesia ceratopyga*, *P. Jeffreysi*, *P. rosea*, and *P. miranda*, for instance, be placed in the same genus? A. Agassiz notices that he was disposed to divide the recognized species; but on the examination of the whole group he determined to let them remain under one head. The propriety of this is a matter for discussion on ordinary zoological principles. It must be remembered that Lovén has shown that there are morphological differences between some of the eight species which he recognizes to belong to *Pourtalesia*, which are without example in any other genus. Yet it seems to be impossible, in his opinion, to break up the genus in order to meet the variability of important structures. In fact he considers that the species seem to be undergoing evolution of a remarkable kind.

There are species now included in the genus (*P. ceratopyga*, *P. Jeffreysi*) which have disconnected apical systems, and others (*P. rosea*, *P. miranda*) which have them compact; and in the first group the postero-lateral interradia are in contact actually and abactinally in most of the species, but in one the contact is abactinal only; in the other group there is not this contact. Yet the structural affinities of the two groups are otherwise so

close that the great differences in the structure of the apical systems and in the interrarial areas seem anomalous. There is some variation in the size, position, and suturing of the basals in one of the species with a disconnected bivium, but there have been no specimens discovered in which any approach to a blending of the two types of apical system has been seen.

There is, moreover, a difficulty in deciding, if a division is to take place, to which of the groups the name *Pourtalesia* should belong, for *Pourtalesia miranda*, A. Agassiz, was the first species described, and the nature of its apical system and the development of its postero-lateral interradia do not appear to coincide with *P. Jeffreysi*, Wyv. Thoms., and its allies.

In describing *P. miranda*, A. Agassiz wrote (Revision, p. 345) as follows:—"The posterior pair of ambulacra extend on both the sides of an elongated plastron to the base of the snout-like prolongation, where they curve sharply upwards, and run close on the abactinal part of the test to the abactinal system situated almost at the summit of the nearly vertical anterior extremity, along a well-marked wedge-shaped ridge extending from the apical system into the rostrum protecting the anus." Again, on p. 346, "The abactinal system, consisting of four large genital openings placed close together, with the madreporic body tolerably well defined in the centre, is situated at the origin of the anterior groove."

On plate xviii., Revision of the Echini, fig. 1, a side view of *P. miranda* shows the postero-lateral ambulacrum of the left side, passing forwards abactinally to the very front of the test. It is also evident in fig. 2 that the postero-lateral ambulacra pass from the peristome on either side of the sternum far back, and that each is continuous. In fig. 3 the apical system is shown to be very excentric in front, and the postero-lateral ambulacra reach it; there is no junction of interrarial plates between the apical system and the bivium. Fig. 9 on the same plate shows most distinctly that the apical system is compact, and that the antero-lateral ambulacra do not terminate in radials which separate the anterior and posterior basals, as in *Echinocorys*.

But in the classification *P. miranda* was placed by A. Agassiz amongst the Ananchytidæ (*op. cit.* p. 344); and in his definition of that group he states, "the apical system more or less elongate, but not disconnected." The difficulty of associating the forms

of *Pourtalesia* with the Ananchytidæ was, however, subsequently noticed by the same naturalist; and in his great work on the 'Challenger' Echini, p. 124, he followed Sir Wyv. Thomson and placed them in a subfamily "Pourtalesiæ" of the family Spatangidæ. Nevertheless A. Agassiz did not consider that the compact apical system of his type, *P. miranda*, militated against the admission of other species with disconnected apical systems into the genus *Pourtalesia*. In fact he appears to discredit the taxonomic value hitherto placed upon the different apical arrangements—compact, elongate, and disconnected. He states (p. 133), "It is remarkable how great is the variation in the extent of the separation of the bivium and trivium at the apical system in the different species of the genus;" and, in describing *P. rosea*, he remarked ('Challenger' Report, p. 141):—"This species is also remarkable for not having, as in other species of the genus, its apical system divided by the encroachment of the posterolateral ambulacra into a bivium and trivium."

It appears that the existence of compact and disconnected apical systems with the correlative interradianal arrangements in one family must be admitted to be consonant with Zoology. Their occurrence in the same genus cannot be maintained, except under most unusual conditions.

It is indeed highly fortunate that the genera *Echinocrepis* and *Spatagocystis*, which have been so carefully described by A. Agassiz and Lovén, should have been discovered, for they let a flood of light into the classification of the species included in *Pourtalesia*. They will be considered further on, but it is advisable to state now that *Spatagocystis* is in alliance with the species of *Pourtalesia* which have disconnected apical systems; and that *Echinocrepis* is allied to *P. miranda* and *P. rosea* with compact apical systems.

The definitions of the genus *Pourtalesia* will be found in the 'Revision of the Echini,' and in the Report on the 'Challenger' Echinoidea; and one was published by Sir Wyville Thomson in the 'Phil. Trans.' The descriptions by Agassiz are positive and also very comparative.

The morphology has especially been studied by Lovén, and published in 'Pourtalesia.' The following definition has been collected from the works of these authors.

Genus *POURTALESIA*, *A. Agassiz*, 1869, *Bull. Mus. Comp. Zoöl.* i. p. 272; 1872-4, *Revision*, p. 344. *Wyville Thomson*, 1874, *Phil. Trans. Roy. Soc.* vol. clxiv. pt. 2, p. 747. *Lovén*, 1883, *Pourtalesia*, p. 82.

Test small or rather large, thin or moderately thick, long, flask-shaped, with a deep inversion of the anterior face, at the lower part of which is the peristome; with a rostrum produced posteriorly and inferiorly, the periproct being above the rostrum. Test subcircular or broadly expanded in front profile, or generally tumid at the sides, flatter actinally, and slightly depressed abactinally.

Apical system very excentric in front, disjunct, with four basal plates perforated by the genital ducts; sutures fused; madreporite in the right anterior, and often between or in the other basals; anterior and antero-lateral radial plates aborted more or less; postero-lateral radials separated by some plates of the odd interradius and disconnected from the basals by plates of the postero-lateral and odd interradia.

Ambulacra apetalous, uniporous, with large wide plates; the anterior large, deeply inverted, forming the peristomial upper margin; antero-lateral flush, placed far forward, nearly transverse; postero-lateral flush, very long, may become discontinuous actinally by the interposition of plates of the postero-lateral interradia; the antero- and a disconnected part of the postero-lateral ambulacra from the lower margin of the peristome, or the antero-lateral may be crowded out.

Interradia with unequal, mostly large, plates; the antero-lateral with a narrow, tall, peristomial plate in one zone (*b*) and a small plate in zone *a*, which may not enter the margin; the postero-lateral meeting abactinally at the median line, and also actinally, or only abactinally, not entering the peristome; the second and third plates of zone *b* of the right postero-lateral area united; the posterior interradius touching or not the peristome, discontinuous or continuous, amphisternous.

Peristome anterior, more or less vertical, at the bottom of the anterior inversion. Periproct above the rostrum. A subanal fasciole around the posterior rostrum. Pedicels similar, pointed, without disks. Spheridia uncovered, numerous, in the lateral ambulacra only. Spines short, slender, fenestrated, often spatulate

or clubbed. Pedicellariæ, some trifid, with circular tops with milled edges.

*Recent.* Atlantic, Pacific, and Antarctic Oceans; 345 to 2900 fms.

This diagnosis will embrace the following species:—*Pourtalesia Jeffreysi*, Wyv. Thoms., *P. laguncula*, A. Agassiz, *P. hispida*, A. Agassiz, *P. phiale*, Wyv. Thoms., *P. ceratopyga*, A. Agassiz, *P. carinata*, A. Agassiz.

Of these the last two have the sternum connected and the interradia 1 and 4 do not unite at the median line actinally, but only abactinally.

The diagnosis will not admit *Pourtalesia miranda* or *P. rosea*, A. Agassiz, which have a compact apical system and the posterolateral interradia separated dorsally. These species should belong to another genus; but as the morphology is as yet unsatisfactory, it is best to place them provisionally in a division of *Pourtalesia*.

Although the diagnosis of *Pourtalesia* just given, will suffice to distinguish it from any other genus, there are some points in the morphology of some of its species which should be recorded, for they are of especial value in showing the aberrant character of the group, how it may be associated, in a family, with other genera, and how slightly it is allied, structurally, to any ancient forms.

Lovén has shown that the inversion of the anterior part of the test not only affects the anterior ambulacrum, but also the peristome and the first plate of the odd interradium. Each side of the peristome, which is narrow and elongate from below upwards, is formed by a narrow and long plate of zone *a* of the antero-lateral interradium. The first plate of zone *b* may enter, so that there is not a "single" peristomial plate; the upper margin is formed of the anterior ambulacral plates. The marginal plates of the lateral ambulacra and the small lip of the posterior, odd, interradium are raised vertically to the actual plane of the test, so that the mouth is entirely within the inversion. In *P. Jeffreysi* the great height of the first plates of the zones (*a*) of the antero-lateral interradia prevents the antero-lateral ambulacra from entering the peristomial margin.

The interradia 1 and 4 in most of the species are large and form a belt round the test, and it is evident, from Lovén's work, that they do not enter into the composition of the peristome, and indeed are remotely posterior to it.

The large plates of these interradia are very striking, and it has been explained by Lovén, *op. cit.* p. 14, that the heteronomy

of the right posterior interradium is from the union of the second and third plates of zone "b." This is unusual amongst the Spatangoidea.

In *P. Jeffreysi* the labrum is very small and is separated from the sternum by the disjunct, first plates of the postero-lateral ambulacra and by the first plates of the anterior zones of the postero-lateral interradia. The sternum is large, is composed of one plate, and is followed by an episternum which is composed of two plates placed side by side and crossed by the fasciole. The periproct is longest transversely, and is surrounded by the 7-9 plates of the posterior interradium, its membrane is more or less divided transversely and covered with small scales.

In *P. Jeffreysi* the first plates of the postero-lateral ambulacra are interposed between the first plates of the antero-lateral ambulacra actinally. Abactinally the last plates of the posterior interradium are separated and intercalated amongst the abactinal plates of the postero-lateral interradia. The true mouth-opening is a slit in a membrane without plates, and the direction is vertical. Some large pedicels are on the posterior ambulacra at the peristomial end, but elsewhere all the tentacles or pedicels are pointed and not prehensile; probably they are all branchial. In *P. laguncula* the labrum is large and long, but barely separates the first plates of the postero-lateral ambulacra, and this also occurs in *P. carinata* and *P. ceratopyga*. The large and numerous spheridia are exposed and are restricted to the lateral ambulacra.

Genus SPATAGOCYSTIS, *A. Agassiz*, 1879, *Proc. Amer. Acad.* vol. xiv. p. 206; 1881, *Report on 'Challenger' Echini*, p. 140. *Lovén*, 1883, *Pourtalesia*, p. 82.

Test moderate in size, long, low, ovoid, thin, very slightly incurved anteriorly, and with a short, small and narrow beak posteriorly; actinally with a downward projecting keel extending from the anterior groove to the beak; abactinally convex, tumid in front, and lower and narrow behind.

Apical system disconnected, part excentric in front; the four basals connected; three genital perforations, and the madreporite in the right anterior basal. The postero-lateral radial plates separated from the basals by several interradiial plates.

Ambulacra apetalous, uniporous; plates varying in width in the different ambulacra, hexagonal.

Posterior interradium with a labrum separated from the amphisternum; postero-lateral interradia meeting abactinally and also actinally. Anterior groove deep and narrow near the actinal margin, not above; peristome in the bottom of the groove. Periproct in a shallow pouch above the short beak and below the overhanging posterior part of the test. Fasciole absent.

*Recent.* South Pacific; 1600–1950 fms.

Genus ECHINOCREPIS, *A. Agassiz*, 1879, *Proc. Amer. Acad.* vol. xiv. p. 206; 1881, *Report on 'Challenger' Echini*, p. 143. *Lovén*, 1883, *Pourtalesia*, p. 82.

Test large, long, subpyramidal, broadest anteriorly, pointed behind; apex excentric in front. Marginal outline irregularly triangular, nipped in at the sides, with rounded angles; margin tumid, with a groove in the anterior part, which is deep and narrow actinally. Actinally flat, with a keel from the end of the anterior groove to the periproct, which is submarginal. Abactinally steep in front and sloping gradually posteriorly; a broad long keel passing backwards and overhanging the periproct. Plates of the test usually large, hexagonal.

Apical system excentric in front, at the vertex, compact, with four basal plates, three perforated by genital ducts; and the madreporite in the right anterior and extending more or less into the other basals; sutures obliterated. The anterior and antero-lateral radial plates aborted; the postero-lateral small and in contact behind the postero-lateral basals.

Ambulacra apetalous, uniporous, flush except where the anterior is in the groove.

The postero-lateral and posterior interradia not reaching the peristome; the long labrum continuous with the sternum and also not entering the peristomial margin; postero-lateral areas neither uniting dorsally nor actinally. Tentacles homoiopodous.

Peristome at the bottom of the anterior groove actinally; the margin formed by the anterior ambulacrum, the antero-lateral interradia, and the antero- and postero-lateral ambulacra. Tubercles small and few, one on a plate abactinally, largest on the sternum, much granulation. Spines slender, short and club-ended. Neither a rostrum nor a fasciole.

*Recent.* South Pacific; 1600 fms.

## VIII.

List of Subclasses, Orders, Suborders, Families, Alliances, Divisions, Subfamilies, Genera, and Subgenera. List of Genera removed or synonymous with recognized genera. List of Genera formerly recognized and now considered of subgeneric value. Tables. List of new Genera and Subgenera.  
Explanation of terms.

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*BOTHRIOCIDAROIDA*, p. 7.

## Genus

*Bothriocidaris*, p. 8.

## Order II.

*PERISCHOECHINOIDA*, p. 8.

## Family I.

*ARCHÆOCIDARIDÆ*, p. 8.

## Genus

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## Genus

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Section I.

Genus

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Family

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Total genera .....	255
Subgenera .....	50
Divisions .....	6

—  
311

These include 12 new genera and 7 new subgenera.

The extinct genera are 161		Subgen. 34							
The genera with extinct and existing species .. 41	}	94	}	16	Divisions 5				
The genera with recent or existing species only .. 53						}	9	}	1
—						—	—	—	—
255			50		6				

Genera synonymous with recognized types or abolished	108
„ placed as subgenera .....	42
	—
	150

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The following genera have been considered to be superfluous or synonyms of others:—

Genus *Palæocidaris*, *Perischocidaris*, *Echinocrinus*, *Protoechinus*, *Typhlechinus*, *Melechinus*, *Xenocidaris* (spines only), *Cystocidaris*, *Palæodiscus*.

Genus *Rhabdocidaris*, *Leiocidaris*, *Dorocidaris*, *Stephanocidaris*, *Phyllacanthus*, *Porocidaris*. (These are now divisions of *Cidaris*.)

Genus *Discocidaris*, *Anaulocidaris*, *Schleinitzia*, *Eocidaris*.

Genus *Hyposalenia*, *Pseudosalenia*, *Poropeltis*, *Tiaris*, *Hemipygus*, *Pseudodiadema*, *Tetragramma*, *Hebertia*, *Echinodiadema*, *Verr.*, *Trichodiadema*, *Plesiodiadema*, *Loriolia*, *Colpotiara*, *Garelia*, *Savignia*, *Gomphechinus*, *Micropeltis*, *Agarites*, *Pygomma*, *Echinocidaris*, *Desm.*, *Coptechinus*, *Opechinus*, *Heliocidaris*, *Chryso-melon*, *Hipponoe*, *Heliechinus*.

Genus *Mortonia* (Gray), *Rumphia*, *Peronella*, *Polyaster*, *Miche-linia*, *Amphiope*, *Lobophora*, *Galerites*, *Trematopygus*, *Parapygus*, *Oolopygus*, *Anthobrissus*, *Clypeolampas*, *Trochalia*, *Asterobrissus*, *Petalaster*, *Cyrthoma*, *Pseudopygaulus*, *Ananchytes*, *Oolaster*, *Stegaster*, *Cibaster*, *Pygopistes*, *Toxaster*, *Heteraster*, *Miotoxaster*, *Globator*.

Genus *Trachyaster*, *Ditremaster*, *Rachiosoma*, *Pliolampas*, *Thegaster*, *Pseudholaster*, *Hypopygurus*, *Atrapus*, *Abatus*, *Desoria*, *Leucaster*, *Tuberaster*, *Plesiaster*, *Opissaster*, *Periaster*, *Perio-naster*, *Paraster*, *Anisaster*, *Brissomorpha*, *Heterobrissus*, *Iso-pneustes*, *Leiopneustes*, *Plagionotus*, *Xanthobrissus*, *Toxobrissus*, *Kleinia*, *Stomaporus*, *Deakia*, *Verbeekia*, *Concophorus*, *Peri-pneustes*, *Trachypatagus*, *Sarsella*, *Leskia*. *Microsoma* is recorded only.

The following genera are now considered to be of subgeneric value:—

Genus (now subgenus) *Goniocidaris*, *Goniophorus*, *Heterosa-lenia*, *Hemidiadema*, *Hypodiadema*, *Pseudocidaris*, *Asterocidaris*, *Acropeltis*, *Microdiadema*, *Dialemopsis*, *Hemipedina*, *Echinodia-dema*, *Pseudopedina*, *Leiosoma*, *Pleurechinus*, *Salmacopsis*, *Psam-mechinus*, *Evechinus*, *Scutellina*, *Monostychia*, *Echinarachnius*, *Monophora*, *Astriclypeus*, *Nucleopygus*, *Rhynchopygus*, *Hardouinia*, *Pygorhynchus*, *Clypeopygus*, *Oriolampas*, *Jeronia*, *Lampadaster*, *Entomaster*, *Opisopneustes*, *Infulaster*, *Macraster*, *Tripylus*, *Moi-ropsis*, *Meoma*, *Cyclaster*, *Loncophorus*, *Plesiaster*, and *Macro-pneustes*.

The following are new genera:—*Eodiadema*, *Placodiadema*=*Plesiodiadema*, *Dunc.*, *Peronia*, *Echinocidaris*, *Goniopneustes*, *Diplothecanthus*, *Plesianthus*, *Lanieria*, *Hagenowia*, *Neopneustes*, *Pseudasterostoma*, *Adelopneustes*, *Gauth.*, *Guettaria*, *Gauth.*

The following are new subgenera:—*Gagara*, *Echinites*, non auct., *Mellitella*, *Dochmostoma*, *Oligopodia*, *Studeria*, *Milletia*.

EXPLANATION OF TERMS.

The following explanation of the anatomical terms employed in the classification is intentionally brief, and further information regarding the anatomy of the Echinoidea can be obtained in the Text-books of Zoology and Comparative Anatomy, in 'The Revision of the Echini' and the Report on the 'Challenger' Echini, by A. Agassiz, in Lovén's 'Études sur les Échinoïdées,' in 'Pourtalesia,' and in 'The Echini described by Linnæus,' by the same author, in works by Perrier, Koehler and Ludwig, and by various authors in the Journal of the Linnean Society, the Quarterly Journal of the Geological Society, and the Quart. Journ. Micros. Sci., during the last decade.

*The Test.*—The individual Echinoid—its covering of calcareous plates and spines, and its internal and external soft structures and organs. The term, when employed in the description of fossil forms, especially refers to the denuded animal, and in the recent forms it is also thus applied; but the shape when the spines remain must be considered, as well as when denuded. The plates of the test are numerous and are in certain regions or systems. The upper surface of a test is *abactinal* or *dorsal*, it has the plates of the *dorso-central* or *apical system* at the apex or elsewhere; the under or opposite surface is *actinal*, and, except in one family, the *peristome* opens out there; the *equatorial* circumference is the *ambitus* or *margin*. There are five *ambulacral* areas, composed of plates reaching in vertical rows from the *Radial* plates of the *Dorso-central* or *Apical system* over the *ambitus* to the *peristome* and sometimes beyond, to the true mouth; and five *interradial* areas, consisting of plates in rows placed between the *ambulacra* and reaching from the *Basal* plates of the *Apical system* to the *peristome* or further. In rare instances, the postero-lateral interradia join abactinally at the median line of the dorsum of the test, and a similar union may occur actinally.

The *peristome* and the *periproct* are at the opposite poles of the test in some Orders of Echinoidea, and such are called *Endocyclica* or *Regulares*. In other orders the *periproct* is beyond the *Dorso-central system* and is somewhere in the median line of the *posterior interradium*, either dorsally or actinally; such forms are called *Exocyclica* or *Irregulares*. The orientation of the *Exocyclica* is not difficult, the *periproct* indicating the *posterior* region of the test; furthermore, the *madreporite* is, in the majority of cases, in the *right anterior Basal plate* of the *Apical System* and often extends to the centre of the system or posteriorly and even more or less beyond. The orientation of one of the *Endocyclica* is evident when the apical system is preserved, and it may be taken that the madreporite is mainly in the *right antero-lateral Basal plate*. Then the *Radial plate* in front of, or anterior to, and on the left hand of the madreporite-bearing basal is the *anterior Radial plate*, and the ambulacrum associated with it is the *anterior* one. In the event of the loss of the apical system, the determination of the axes of the test may usually be settled by employing Lovén's method (Études, pp. xi et seq.).

The margin of the *peristome* formed by *ambulacral* and *interradial plates* has a membranous tissue connected with it and is more or less covered with

plates; this *peristomial membrane* surrounds the *Stoma* or true mouth and is attached to the pyramids of the *Jaws*; but in the edentate kinds, or *Nodostomata*, the inner edge is free. In the *Gnathostomes* the *Jaws* are internal and the *teeth* project free in the *Stoma*. The edge of the peristome may be *grooved* or *incised* or not, and in the first instance *external branchiæ* are present. Within the test, close to the margin of the peristome, are modifications and fusions of the interradial and of the ambulacral plates which, as *ridges* and *processes*, united or not, surround or underlie the *Jaws* and give attachment to their muscles; the structure is the *Perignathic Girdle*, formerly called "*Auricles*." The ridges are interradial, as in *Cidaris*; the processes are ambulacral. Leading from the gullet within the test, and passing through the *pyramids of the Jaws* and upwards over the inner regions of the ambulacra, are five variably developed finger-shaped organs, in some genera—"Stewart's Organs," or *Internal branchiæ*. *External branchiæ* occur in some orders which are thus *ectobranchiata*. The orders without them are *anectobranchiata*.

The *ambulacral plates* are always perforated by *canals* (one, two, or many) ending externally in pores; the *interradia* are more or less perforated in the *Clypeastroida*; the *water-system* from within becomes connected with *Tentacles* or *Pedicels* which are placed outside the test, their bases covering a *pore* or a pair. The surface of all of the plates of the test is tuberculate or granular, and may have *epistroma*; the tubercles carry *spines*, some minute ones, and some granules support the *stalks* of *pedicellariæ*; *spheridia* occur in the actinal part of the ambulacra. They are usually visible, but may be hidden.

*Plates*.—Tests may be *rigid* or more or less *flexible*. Plates are more or less geometrical, calcareous pieces forming the *interradia*, *ambulacra*, *dorso-central system*, *perignathic girdle*, and are found upon the *peristomial* and *periproctal* membranes; they are named according to those parts of the test, and may be numerous or few. Composed of lax or close branching rods of carbonate of lime and intermediate organic structure, of cleaving calcite in fossils. A plate has an *inner* or visceral surface, an *outer* with *tubercles*, *granules*, and *epistroma*: and edges, the more or less transverse of which are dorsal and actinal or aboral and adoral; the remaining edges are vertical or aslant. The edges of plates are in contact with those of others around, and the plane of junction, or union, is the *Suture*. The edges in contact may be fused or inseparable, or in simple contact through the intervention of a thin organic tissue; or the edge of one plate may carry knobs which fit into sockets upon the opposite edge (dowelling); or *laminae* of one edge dovetail into grooves in opposite edges. The outer part of the suture (the *line of suture*) is often visible at the surface of the test between plates, and may be a simple line, or a *slight* or *deep groove*, with or without *pits* and *deep undermining hollows*. Plates may be united by soft structures in which there is no carbonate of lime, and then there is no suturing, but more or less flexibility of the test or part of it. The plates of the *peristomial* and *periproctal* membranes are thus separated. The sutures which are vertical and pass down in the median line of the interradia and the ambulacra are *Median*; the sutures between the ambulacra and interradia are *Ambu-*



*lacro-interradial*; all others are *Transverse*. *Overlap* or imbrication of the edges of plates may occur when the plates are separated by organic material, although there is no *obliquity* of the thin edges of the plates. *Overlap* usually occurs when the plates are in direct contact, and hence *obliquity* of the edges; the direction of the plane of suture is then not at right angles with the surface of the test, but more or less *aslant*. In *overlap* the edge of a plate overrides or overlaps the corresponding edge of the plate placed *actinally* or *dorsally* or at the side. The *overlap* occurs both in thin and in thick tests and has definite directions. The *overlap* of the *ambulacral* plates is *adoral* or *actinal*, that is the *actinal* edge of a plate overlaps the *abactinal* edge of the plate situated below or *actinally* to it. On the other hand, the *overlap* of the *interradial* plates is *aboral* or *abactinal*, and the *abactinal* edge of a plate overrides the *actinal* edge of the plate placed *dorsally* to it. It is understood that the observation must be made of the outside of the test. *Overlap* may occur at the sides of plates and in the *interradia*, from the median vertical line outwards.

*Coronal* plates are those between the *peristomial* margin and the apical system; *peristomial* marginal plates surround and form the *peristome*; *buccal* or *peristomial* plates are in rows or are isolated within the *peristomial* margin in the line of the *ambulacra*; *periproctal* plates are upon the *periproctal membrane*; *anal* plates are close to the anal orifice in the *periproctal membrane*.

*Interradial* plates are simple and variable in number. *Ambulacral* plates are usually in two vertical rows, but there may be more; the plates are either simple or *compound*; and in the first case they are in the great majority of instances *primaries*, that is they extend from the outer edge of an *ambulacrum* to the *median suture* of the area. When *compound* they are composed of two or several *components*, all of which are joined by sutures and form a geometrical plate; some components are *primaries*, that is extend from the side of the *ambulacrum* to the median line; others are *demi-plates* and do not reach the median line. The *direction of the lines of suture* of the components of a *compound* plate varies in different families.

A plate is said to be *occluded* when it reaches the median line, but does not touch the *ambulacro-interradial vertical suture*. The plate may be *isolated*, and then it is shut out from the median line as well as from the edge of the *ambulacrum*. Each plate, whether simple or forming part of a *compound* plate, or a solitary *demi* or *occluded* plate, is perforated either by two canals, and shows externally a pair of pores, or by a single canal, or by several, each having one pore externally. (See *Tentacles*.)

Tubercles are *primaries* when fully developed and larger than others, which are "*Secondaries*." They have a *base*, the "*Boss*," which carries the "*Mamelon*;" the upper part of the *Boss* may have *crenulation*, or be *crenulated* (more or less vertical ridges and grooves all round the upper part) or not, and then it is said to be *plain*; the *mamelon* may have a circular foramen leading downwards from the apex for a slight distance, and is then "*perforated*," or the perforation may be absent, and the *mamelon* is "*imperforate*." A plain or a sunken space may surround the base of the *Boss* of primary tubercles, which is called the "*Scrobicule*" or

*scrobicular area*: its outer limit, more or less circular, is the *scrobicular circle*, and may or may not be perfect; if not, the scrobicule of one tubercle will be found to merge into those of the tubercles placed dorsally and actinally to it, and is "continuous." *Secondary tubercles* may or may not have scrobicules. Very small tubercles incomplete in their division into parts are *miliaries*. *Granules* are more or less nodular projections of the test, and may be large and distant or very numerous and like shagreen, and all intermediate sizes are seen. The tubercles carry *spines*. The *miliaries* and *granules* may carry small spines or pedicellariæ.

Lovén has lately pointed out that much of the ornamentation of certain genera, such as ridges, all moniliform, pedunculate, and large granules, linear or vermiform elevations, and groovings, is due to the calcification of a membrane placed in early life upon the plates. This ornamentation is *Epistroma* (Lovén, Ech. desc. by Linnæus).

*Dorso-central or Apical System*.—This is abactinal or dorsal, and consists of *Basal plates*, *Radial plates* united by sutures or fused or separated by soft tissue (formerly termed Genital and Ocular), the madreporite, and of the periproctal plates in some, and sometimes of intercalated plates. In the Endocyclica the *periproctal ring*, composed of basal and sometimes of radial plates, surrounds the *membrane* and *plates* of the *periproct* and the *anal opening*, with or without anal plates. The *genital glands*, within the test, open externally by *ducts*, and one or more of them may perforate a *Basal plate*, or the perforation may be in the interradius beyond the dorso-central system. All or some of the basal plates may be thus perforated. Each *Radial plate* has a canal with a single or double orifice, and in the Palæechinoidea more than one canal may exist; the position of the opening differs, but it appears to refer to the *primitive large tentacle*, and not to an ocular organ. The *Radial plates*, five in number, may either be placed within the angles formed by the actinally projecting Basal plates, and are then *external*, or one or more may project between the Basal plates and separate them. In the Endocyclica if the Radial plates touch the margin of the periproct they "enter the ring." The *Basal plates* are either five or four in number, and when the latter number prevails it is due to the absence or incomplete development of the *posterior Basal plate*. The *Periproct* is within the *Dorso-central* system in the Endocyclica, and there are plates covering it more or less. The *plates* may be few and symmetrical and triangular, or numerous and more or less ovoid, circular, or irregular in outline, and placed concentrically, the largest anteriorly. A *sur-anal* plate may exist and is large, and in front of the anal orifice or in front and to the left side; rarely a somewhat *continuous pavement* of plates occurs. The plates carry spinules, tubercles, granules, pedicellariæ. The shape of the *periproct* varies: it may be circular, elliptical, or pyriform; it may have its long axis along the median line of the dorsum or obliquely to it in the Endocyclica. When the test is Exocyclic, the Basal plates may be in *contact* at their sides, forming a "compact" system; when some of the *Radial plates*, i. e. the *antero-lateral pair*, separate the *Basal plates*, and unite along the median line, pushing the *posterior basal plates* backwards, the system is

"*elongate*;" when the *Apical* system has the *posterior pair of Radial plates* not in contact with it, but placed *far posteriorly and separated from it* by the junction of *interradial plates* along the *dorsum*, it is said to be "*disjunct or disconnected*."

The *Basal plates* project into, or are in contact with, *interradia*, and the *Radial plates* surmount *ambulacra*. In a great many genera "the *Madreporite*" is in the *right anterior basal plate*, which then is the largest; the *left anterior basal plate* is at that side of the *right anterior*, and the *postero-lateral basal plates* are immediately posterior to the anterior pair, except in *Elongate apical systems*, where, as has been noticed, the *antero-lateral Radial plates* intervene. The *posterior Basal plate* is in the *antero-posterior median line* of the *dorsum* of the test and is in contact on either side and to the front with the *postero-lateral basal plates*; or it may be absent.

The *anterior or odd Radial plate* is in the *median line* anteriorly, and is in the angle made by the *antero-lateral basal plates*; the *postero-lateral Radial plates* are on either side of the *posterior Basal plate*. When there is no *posterior Basal plate*, the *posterior pair of Radial plates* may come in contact and close the system posteriorly, or they may be separated by the *Madreporite* extending backwards. The *anterior Radial plate* is No. III., the *left anterior Radial plate* is No. IV., the *left posterior* is No. V., the *right posterior Radial plate* is No. I., and the *right anterior plate, usually with the madreporite*, is No. II. The *ambulacra* corresponding to the plates are similarly numbered. The *right anterior basal plate* is No. 2, the *opposite or left anterior Basal plate* is No. 3, the *left posterior plate* is No. 4, the *posterior Basal* is No. 5, and the *right posterior Basal plate* is No. 1. The *interradia* in relation with the *Basal plates* are similarly numbered. (See Lovén, *Études*.)

*The Madreporite*.—A cribriform structure consisting of *canals*, tubular in shape, variable in number, with reticulate carbonate of lime between them and forming their walls, opening at the surface of the test, the orifice or orifices being minute and rather close, leading into the test to a canal which is in communication with the water-system and a renal organ. It has no especial plate and the tubules of the body may be *restricted* to the area of the *right anterior Basal plate*, or may extend and perforate other *Basal plates* and even some *interradial plates*. The *Madreporite* may exist so as to *separate* some of the *basal plates* in the *Exocyclica*, to form much of the centre of the system, and it may pass backwards separating the *posterior Basal plates* and even the *posterior Radial plates*, and may abut against the *posterior interradium*. In some *Clypeastroida* there may be but one pore in the *Madreporite*, or two or three situated along a narrow groove; in the majority the body may be *central*.

When a *Madreporite* in the *Exocyclica* is bounded posteriorly by the *posterior pair of Basal plates*, Nos. 4 and 1, the *apical system* is *Ethmophract*; but when the *posterior Basal plates* and the *Postero-lateral Radial plates* are pushed on one side by the *Madreporite*, the arrangement is *Ethmolysian*. (See Lovén, *Études*.)

In the *Exocyclica* the *periproct* is in the *median line* of the *posterior ambulacrum*, beyond the *apical system*; it may be circular, elliptical,

oval, large or small, and even deformed and oblique; it may be supra-marginal, marginal, or infra-marginal; it has plates surrounding the anus, sometimes numerous, rarely few and triangular.

*Ambulacrum*, one of the five *ambulacra*. (See *Test, Dorso-central System, Plates*.)—Consists of an *interporiferous area*, which is placed between the two *poriferous zones*. The *ambulacra* may be straight, curved, wavy, subsigmoid, flaring, broad, narrow, flush or sunken, according to the usual meaning of the words; their path is dorsal, ambital, actinal, peristomial, and buccal—these being the regions of the test passed over. They are *similar*, or, when the anterior one differs from the others in its pores, *dissimilar*; they are either *Close* at the Apex, or *Disconnected* when the posterior Radial plates are disjunct. They are named according to their position, and are:—1, *Anterior or odd*; 2, *Antero-lateral, right and left*; 3, *Postero-lateral, also right and left*. Each *ambulacrum* being associated with a *Radial plate*, assumes the number of that plate in Lovén's terminology. *Ambulacra* may have their dorsal portions petaloid and the rest simple, except often near the peristome. In the *Exocyclica* the anterior *ambulacrum* and the antero-lateral pair are sufficiently connected to form a *Trivium*, in contradistinction to the postero-lateral pair, which then form a *Bivium*. The termination of the *ambulacrum* at the *Peristome* is the *peristomial margin* of it. The *petaloid* parts are either flush with the test, or project and are tumid, but most commonly they are slightly or considerably sunken, and in the last instance they frequently are *Marsupia*, or receptacles for the immature young; they may be in deep and narrow or broad grooves.

The areas have primary and secondary tubercles in vertical rows, or the last kind may be irregularly disposed or in scrobicular circles around the *primaries* (see *Plates*). *Granules* occur and *Epistroma*.

The *poriferous zones* are on either side of an *interporiferous area*, except in some Palæozoic genera, where all the *ambulacrum* is *poriferous*. The arrangement of the pairs of pores may be in *simple series*, that is to say one pair is placed over the other from peristome to apex; or they may be placed so that there are two vertical series, one nearer the *ambulacro-interradial suture* than the other, they are then termed "*biserial*" (bigeminal of authors); or there may be three vertical rows of pairs, the arrangement being "*triserial*" (trigeminal); or there may be a crowded and apparently disorderly arrangement of the pairs near the peristome, and it is "*Polyserial*."

*Simple series* of pairs of pores are either absolutely straight or in *arcs* of three or more pairs. The *innermost*, and therefore the lowest or *adoral* of the pairs of an *arc* of three pairs, is usually connected with the *adoral plate* of a *compound plate*, and when there are *biserial* pairs the distribution of the three pairs in an *arc* is closer and wider apart laterally (see *Echinothrix*, fig. 7, pl. v. Linn. Soc. Journ. xix.), or as in *Micropyga* (see same plate, fig. 11). The *adoral pair* of the *triplet* is then not always the most internal of the three. (It is clear that there are three pairs of pores to each compound plate of the *biserial Micropyga*, and therefore the word bigeminal, which used to be the term, is incorrect.) Pairs are said to be in

*oblique series*, or to be *oblique*, when there is an outward slant of three or more consecutive pairs from above downwards; but it will be found, as a rule, that the *highest*, and therefore innermost, of the three pairs is the *adoral pair of a compound plate*, as in *Pedina*. In every pair the pore which is nearest the interporiferous area is the adoral of the two, or was so at an early age, and is or was in contact with the transverse suture of the plate; but during the growth of plates the pair may become removed from the neighbourhood of the suture, and the adoral character lost. *Uniporous zones* occur in parts of ambulacra and sometimes throughout. *Polyporous ambulacra*, as in Clypeastridæ, are those in which besides the usual pairs numerous *single pores* exist throughout or in part of the ambulacrum. Pores are *similar* when both of a pair are the same in shape; *dissimilar* when the outer pores of a series of pairs differ in shape and size from the inner series. Pores become *obsolete* or *rudimentary* or very small in the zones between Internal Fascioles and the Apical system. Pairs of pores may either be *flush* with the test or open out in slightly raised elliptical rims, called *peripodia*; there is usually a *septum* between the pores of a pair, and there may be a *costa* between each pair of pores.

Ambulacra are *simple* when the pairs of similar pores keep to slightly curved lines of vertical direction, as in *Cidaris*, *Diadema*, and *Echinocorys*; and they are then often termed *apetaloid* in contradistinction to the *petaloid* condition. *Petaloid ambulacra* are those which enlarge between the apex and the ambitus, and contract again more or less perfectly before reaching that region; they have large pairs of pores, and the outer pores of pairs are usually broader than the inner, and this dissimilarity increases with the boldness of the curvature of the zones. *Subpetaloid* is a term given to ambulacra similar to those just noticed, but the pairs of pores do not tend to close distally. The pairs of pores at the peristome or close to it may be simply *crowded*; or they may be in a pattern forming a kind of petal, some of the pairs being wider apart than others, and some put out of place and "*doubled*," this arrangement is a "*Phyllode*." When accompanied by ornamentation of the *tumid interradiial peristomial margins* (bourrelet), the whole forms a "*Floscelle*."

The "*Tentacles* or *Pedicels*" of the ambulacra are placed over the peripodia, and single, and may be *prehensile* and end in a *disk*, or be *branchial* or *penicillate*\*; they may be of the same kind or they may differ in the same ambulacrum, especially if there are fascioles crossing the areas, and then the tentacles of the peristomial region differ from those of the dorsal. The tentacles of the ambulacra are *homoiopodous* when they are similar, and *heteropodous* when they differ in shape, construction, and function; *subheteropodous* when the abactinal tentacles are partly branchial and partly and feebly prehensile, the actinal being with disks; *subhomoiopodous* when the actinal tentacles, although modified, still have suckers. *Branchial incisions, grooves, or cuts* are notches in the *peristomial margin* for external branchiæ, are on either side of *each ambulacrum* in some orders of the Endocyclica, and there may be a "*Tag*"

\* O. F. Müller, 1789, 'Zool. Danica,' vol. iii. p. 18.

or piece of plain test passing for some distance dorsally from the grooves, and they are in relation to small tufts of *external branchiæ*.

*Spheridia* are either placed visibly upon short stalks in the ambulacra, usually near the peristome, or they may be partly or entirely covered by test; they vary in number and exact position, and are opalescent spheroidal bodies. (See Lovén, *Études*.)

*Interradium*.—One of the five areas which are placed between the ambulacra, and reach from the basal plates of the apical system to the peristome (*coronal*), and in some instances to the mouth (*peristomial*).

The plates are more or less geometrical and in vertical rows, and are united by transverse and oblique sutures with those above and below, and a median suture (or in some Palæozoic forms sutures) unites them also at the side. Variable in shape and in number; when in more than two vertical rows those nearest the ambulacro-interradial sutures are "*ambulacral*." In the Euechinoidea the interradia correspond with basal plates, and are numbered as they are, and receive the same orientation. In the Exocyclica the *posterior interradium*, No. 5 (Lovén), has the periproct occupying some space at the median line or suture; and in Spatangoida the *posterior interradium* is long, and often forms actinally a *sternum*, preceded at and towards the peristome by a *labrum*, forming the posterior edge of the peristomial margin, followed or not by an *episternum*. When there is a large plate on either side of the median line of the sternum, the test is *amphisternous*; and when there is more or less of a zigzag and the plates are not arranged symmetrically on either side of a median line, the test is *meridosternous* (Lovén, 'Pourtalesia'). The interradia may enter the peristomial margin, each with two plates, or with only one, as in *Cassidulus* and in Spatangoids and Clypeastridæ. The interradia are usually *continuous* from apex to peristome, and in Cidaridæ and in some Palæoechoinoidea they are continued beyond the peristome associated with ambulacral plates to near the stoma. But *discontinuity* may happen by the enlargement of ambulacral plates blocking out the union of the *first and second peristomial interradial plates*, leaving a circle of ambulacral plates, as in *Mellita* (Lovén, 'Études'). There is a want of symmetry and similarity between the arrangements of the plates in the *postero-lateral pair of interradia* (Nos. 1 & 4), and this is produced by the fusion of certain plates in the actinal region of the *right postero-lateral interradium* No. 1 (Lovén). The anterior part of the *interradium* is *zone b*, and the *posterior* zone next to the postero-lateral ambulacrum is *zone a*. (For descriptions of this want of symmetry, ancient and modern, see Lovén, 'Études'.)

Union of the second and third (2 & 3) plates of *zone a*, no such union happening in the corresponding zone of interradium 4, is *normal heteronomy* of interradium 1; union of the second plates of *zone a* and *zone b* in interradium 1 is *ancient heteronomy*. Irregular heteronomy when the plates 2 & 3 of *zone b* unite with plate 2 of *zone a* in interradium 1, the plates 2 of both zones of interradium 4 also uniting (*Palæostoma*).

The *Peristome*, more or less central and actinal in the Endocyclica, is sunken or flush, decagonal, pentagonal, with or without branchial incisions or cuts; the margin is composed of ambulacral and interradial plates,

and these may or may not be carried on as far as the true mouth; or isolated buccal plates occur.

In the Exocyclia the peristome varies in shape and position, usually actinal, and usually excentric in front; it may be quite anterior, as in *Pourtalesia*. It may be elliptical, decagonal, circular, oblique, pentagonal, or semilunar with a posterior labrum. It has a plating upon its membrane.

*Perignathic Girdle* (see *Test*) does not occur in Spatangoida: is *continuous* when there are *processes* ambulacral in development, usually arched over, and connected at their sides by *ridges* consisting of turned up and fused inter-radial plates (Duncan, Journ. Linn. Soc. xix. p. 179); is *discontinuous*, as in *Cidaris* and Clypeastroids, when there are either simple ridges or simple processes without their union.

*Jaws*.—In the Endocyclia the *pyramids* are five in number, and each has a *grooved* or a *keeled* tooth, pointed actinally. The pyramids are in muscular contact at their sides; and at their upper junction is a “*brace*” radiating outwards from the central axis of the jaws, which is occupied by the œsophagus; a long, bifid process, the “*rotula*,” or *compass*, is above each *brace*. The *projecting* part of the pyramid bulges outwards at the median line, and in some genera it is solid almost to the upper part, a very small notch or foramen existing; but in others there is a large *foramen*, which is arched over by apophyses of the sides of the top of the pyramid; the tooth is just within this median projecting part. The jaws of the Clypeastroids are differently formed, and in the majority of genera overlie and are rarely within the single or double *discontinuous perignathic processes and ridges*, as the case may be. They have each pyramid more or less *concave* and *re-entering* at its median line; the projection is at the junction of two pyramids over the ambulacrum within the test, the reverse of what occurs in Cidaroida for example. In Clypeastroida the jaws are low, often *unsymmetrical*, and the teeth are *aslant*, or even nearly *horizontal*. Moreover, the *foramen* is absent, and the *compasses* also, the *braces* being rudimentary and not found at the upper junction of two pyramids.

*Fascioles* are narrow bands of close granular ornamentation, which support rudimentary spinules and pedicellariæ. The “*peripetalous*” fasciole environs the petaliform parts of the ambulacra, often keeping close to them; the “*lateral*,” or more properly termed “*marginal*,” encircles the test about or above the ambitus; and the peripetalous fascioles may have a *posterior lateral branch* passing beneath the anus, sometimes called “*infra-anal*.” The “*subanal*” fasciole encloses a space or *plastron* perforated by pairs of pores, placed beneath the anus, and it may send *anal branches* upwards on either side of the anus, and they may enclose it, forming an *anal fasciole*. The “*internal fasciole*” crosses the ambulacra at a greater or less distance from the apical system. The *internal fasciole* and the *subanal fasciole* are accompanied by modifications in the structure of the plates and tentacles enclosed within their areas, and are of much importance in classification. Spatangoids have *fascioles*, and those genera of the group without them are

*Adetes*, the genera with *subanal* fascioles are *Prymnodesmia*, and those without them and with other fascioles are *Prymnadetes* (Lovén).

*Spines* vary greatly in dimensions, and in the shape and nature of the transverse section; may be hollow or more or less solid and reticulate centrally; externally with close or distant wedges, or a merely solid circumference. They consist of a shaft variously ornamented, of a base which is hollowed for the condyle or cup part of the joint for the reception of the ball or mamelon of the articulating tubercle. The base may be plain, or it may be crenulate, and will then correspond with a crenulation on the ridge surrounding the base of the mamelon. The crenulation varies in amount, and it may be present in some and absent in other tubercles and spines upon the same test. The opposed crenulated surfaces give attachment to the dense capsule of the joint, and there are no muscular fibres in connection with them. Above the base of the spine, is usually, but not invariably, a more or less symmetrical collar, which projects beyond the shaft, and is sloped upwards to the shaft and ornamented with the striations or grooves and ridges of the spine. The muscular fibres which move the spine are inserted just below the collar, or upon the whole of the underpart of it, and they arise from the edge of the scrobicule close to the scrobicular circle of granules or tubercles, and may form a sheath. Some spines are fixed, and arise at once from the test, as in *Podocidaris*. (For general and especial structure see A. Agassiz, 'Revision,' and Reports on the 'Challenger' and 'Blake' Echini; Mackintosh, Trans. Roy. Irish Acad. 1878.)

*Pedicellariæ* have a short or long calcareous stem articulated upon granules, and a short or very long flexible and soft part upon which is the head, formed by either two or by three valves. The stem may be glandular or not, and glands exist in many instances within the head, also muscular fibres and nerves. *Pedicellariæ* have been classified under three terms, and O. F. Müller, 1788, Zool. Dan. vol. i. p. 16, called them *P. globifera*, *P. triphylla*, and *P. tridens*. The first have a spherical head and no neck, the second have a bilobate short head and a produced neck, and the third have a bilobate long head often with slender valves and a neck. These terms are quite as useful as the more modern equivalents—*P. gemmiforma*, *P. ophiocephala*, and *P. tridactyla*. The "*Globifera*" of Hamann are large tripartite glands without an internal calcareous support.

The figures of *Pedicellariæ* in the Zool. Danica, vol. i. pl. xvi., 'Revision of the Echini,' and in the Reports upon the 'Challenger' and 'Blake' Echini, by A. Agassiz, should be studied; also Valentin, 1841, Anat. Gen. *Echinus*, in Agassiz, Monogr. d'Éch. viv. et foss.; Sladen, 1880, Ann. & Mag. Nat. Hist. ser. 5, vi. p. 102; Hamann, 1886, Sonder-Abdruck aus den Sitzungsber. d. Jenaisch. Gesellsch. f. Med. u. Naturw. See also remarks by Döderlein, 1885, Archiv f. Naturg. (Wiegman.), i. p. 82.



SUPPLEMENTARY NOTE.

The following Note was written during the printing of this "Revision" (Oct. 16th, 1889).

An important work came to hand after the reading of this "Revision," and the following are necessary remarks:—

Explorat. Sci. de la Tunisie, Ech. Foss., 1889, MM. Thomas et V. Gauthier.

Genus *Opisopneustes*, Gauthier, 1889, p. 2. This, according to the system adopted in this "Revision," is a subgenus of *Hemipneustes*.

There is not sufficient structural difference between *Holaster* and a genus *Pseudholaster*, Pomel, 1883, adopted by M. Gauthier, and the first-named genus absorbs the other.

*Plesiaster*, Pomel, adopted by M. Gauthier (p. 26), is said to be a *Micraster* with a peripetalous fasciole; but, considering the shape and the distribution of the species of *Metalia* from Sind, and the existence of the genus *Meoma*, it is impossible to recognize the proposed genus without further knowledge about the anatomy of the test.

Had M. Gauthier had the advantage of seeing the great collection of species of *Plesiolampas*, Duncan and Sladen, from Sind, he would have placed his genus *Hypopygurus* in it. There is no distinction.

*Pygopistes*, Pomel, 1883, admitted by M. Gauthier, comes within *Catopygus* (see *ante*, p. 185). *Parapygus*, Pomel, is inseparable from *Echinanthus*.

Genus *Adelopneustes*, Gauthier, 1889, *op. cit.* p. 52, is a good and most interesting genus belonging to the Echinoconinæ. It has the characters of *Echinoconus*, but the ambulacral plates are few, high, and single, and each has a pair of very small pores. Cretaceous; Tunis.

*Rachiosoma*, Pomel, 1883, is a *Cyphosoma*.

*Thegaster*, Pomel, 1888, when compared with fossil and recent *Fibulariæ* (see especially the tumid forms described by A. Agassiz), clearly is a true Fibularine, and synonymous with *Fibularia*.

*Pliolampas*, Gauthier?, *op. cit.* p. 97, appears to be a *Palæolampas*, Bell, with a produced rostrum and periproct.

*Orthechinus*, Gauthier, p. 105, admirably described, covers the same ground as *Thylechinus*, Pomel (amended), see p. 89 of this "Revision." M. Gauthier's generic name is the best.

Subgenus *Radiocyphus*, Cotteau, 1888 (genus), *Compt. Rend. de l'Acad. des Sci. vol. 107*, is a subgenus of *Acanthechinus* (see *ante*, p. 289) with perforate and crenulate tubercles.

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### ADDENDA ET CORRIGENDA.

PHORMOSOMA, p. 42. Prof. Jeffrey Bell has shown (*Ann. & Mag. Nat. Hist.* 1889, ser. 6, vol. iv. p. 436), during the printing of this Revision, that in *Phormosoma placenta*, Wyv. Thoms., the internal branchiæ, or "Stewart's organs," may be present in a rudimentary or vestigial condition. He observes that the organs are not to be traced in *P. bursarium* and *P. tenue*; but he does not lay much stress upon this, as the specimens, unlike those of *Phormosoma placenta*, had been for many years in spirit. The longitudinal internal muscles, so well described by Drs. Sarasin in *Asthenosoma*, are absent in *Phormosoma*. It is difficult to make out whether the indications of the presence of the organs, in the drawing given by A. Agassiz of *P. tenue*, 'Challenger' Report, pl. xiv. fig. 2, are really not intestinal. This appears to be the case in pl. xii. fig. 2.

It is necessary, thanks to Prof. Bell's work, to make the following corrections:—

*Phormosoma*, p. 42, should be in a new subfamily of Echinothuridæ.

Therefore:—

P. 40, 5 lines from bottom, *after* "a series of longitudinal muscles" *add* "may exist or not;" and 6 lines from bottom, *after* "internal very large" *add* "or ill developed."

P. 43, 14 lines from bottom, *add* "Internal longitudinal muscles absent; *internal branchiæ small or rudimentary.*"

P. 44, 20 lines from bottom, *add* "*Internal branchiæ large; internal longitudinal muscles developed.*"

P. 45, 13 lines from top, *for* "Cyphosomidæ" *read* "Cyphosomatidæ."

P. 207, 20 lines from top, expunge "Syn. *Guettaria*, Gauthier, 1887. *Entomaster*, Gauthier, 1887."

*Passim*, *for* "Péron" *read* "Peron."

M. V. Gauthier has obligingly sent me his generic descriptions of *Guettaria* and *Entomaster*, which were not available before the last sheet but one of this work was in the press.

Genus GUETTARIA, Gauthier, 1887, *Assoc. Franç. pour l'Avanc. d. Sci.* (Toulouse), p. 528.

This genus is allied to *Cardiaster*, and has a deep narrow anterior groove actinally, with a sunken and almost circular peristome in it; the tubercles are larger than in *Micraster*, and there is a posterior notch resembling that of *Hemipneustes*. There are two large pores besides the small tentacular pore in each antero-lateral radial plate.

Cretaceous: Africa, Tunis, and Madagascar.

The genus *Entomaster*, Gauthier, 1887, *op. cit.* pl. xvi., appears to be of subgeneric value, like *Lampadaster*, Cott. I place it provisionally as a subgenus of *Holaster*.

Cretaceous: Africa, Tunis.